LABS REVIEW: AMD RADEON 7900 XT & XTX

apc

SINCE 1980

THE SMART CHOICE GPU

FEBRUARY 2023 #516

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STOP USING GMAIL & OUTLOOK

INSIDE: BETTER, SAFER & ***MORE PRIVATE*** OPTIONS

RETRO TECH

THE 8-BIT OS REVIVAL

AI TO DIE FOR

KILLER ROBOTS ON THE BATTLEFIELD & BEYOND

THE *NEW* WINDOWS 11

ULL GUIDE TO THE BIG UPDATE

S TIME TO MOVE ON ROM WINDOWS 10

UPGRADE YOUR PC & LAPTOP

M.2 SSD GROUP TEST

14 DRIVES LABS TESTED

HOW TO CHOOSE THE PERFECT SSD FOR YOU • HOW TO KEEP YOUR DRIVE HEALTHY
PCIE GEN3 VS GEN4 • CAN SATA STILL CUT IT?

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Vigor2927 Series

Dual-WAN broadband routers with 1 x fixed GbE WAN port and 1 x configurable GbE WAN/LAN port, 5 x GbE LAN ports, SPI Firewall, 802.11ax/ac Wi-Fi, and 50 x VPN tunnels including 25 x SSL-VPN tunnels

apc HOT PRODUCT

50x VPN

Vigor2927ax (WiFi 6, AX3000)

- 1 x fixed GbE WAN port and 1 x configurable GbE WAN/LAN port for Failover, Load Balancing and High Availability mode
- Two USB 2.0 ports for connection to two 3G/4G LTE USB modems, FTP server, network printer and thermometer
- 5 x Gigabit LAN ports with multiple subnets and 60,000 NAT sessions
- 50 x VPN tunnels (including 25 x OpenVPN/ SSL-VPN tunnels) with comprehensive secure protocols
- Fast VPN throughput, VPN load-balancing and backup for site-to-site applications
- 16 x VLANs for secure and efficient workgroup management
- IPv6 & IPv4; Up to 1022 IP addresses and 8 IP subnets
- Integrated IEEE 802.11ax (WiFi 6, AX3000) wireless Access Point; dual band; up to 2402 Mbps throughput (ax model)
- Hardware Acceleration and Hardware QoS for up to 8k NAT and routing connections
- High Availability mode
- Object-based SPI Firewall and CSM (Content Security Management) for network security
- Supports VigorACS 2 and VigorACS 3 Central Management Systems for remote management
- SD WAN capability when used with VigorACS 3
- Central VPN Management for 8 remote Vigor routers
- Central AP Management for deployment of 20 VigorAP's
- Central Switch Management for 10 VigorSwitches
- 2 years back to base warranty

Vigor2135 Series

Broadband routers with 4 x GbE LAN ports, SPI Firewall, 802.11ax/ac Wi-Fi and 2 x VPN tunnels including SSL-VPN tunnels

2x VPN

Vigor2135ax (802.11ax, Wi Fi 6)

- NBN (National Broadband Network – Australia) Ready to connect to NTD (Network Termination Device)
- 1 x Gigabit WAN port with 2 x USB ports for 3.5G / 4G Mobile Failover
- 4 x Gigabit LAN ports with 50,000 NAT sessions and IPv6
- NAT throughput over 600Mbps
- IPsec VPN throughput at 150 Mbps (AES 256 bits)
- Object-based SPI Firewall, Content Security Management (CSM) and QoS
- IPv6 & IPv4
- Integrated IEEE 802.11ax (AX3000) wireless Access Point (ax model)
- 802.11ac (AC1300) Wi-Fi up to 400 + 867Mbps speed (ac/Vac model)
- 2 x FXS VoIP (Vac model)
- 2 x VPN tunnels including OpenVPN/ SSL-VPN tunnels
- 2 x USB ports for 3G/4G Backup, FTP server, network printer or thermometer
- Supports Central AP Management for deployment of 2 Vigor Access Points
- Support VigorACS 2 and VigorACS 3 Central Management Systems for remote management
- 2 years back to base warranty

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EDITORIAL

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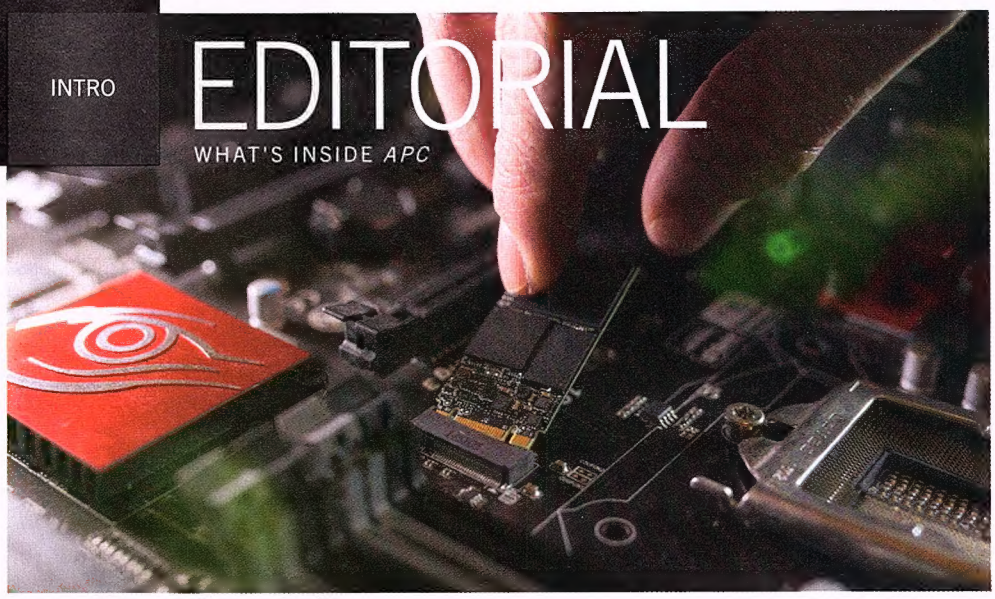

EDITORIAL

The SSD revolution

Luxury or commodity?

BEN MANSILL
My first mass-storage device was a shoebox full of Amiga 500 floppies.

Remember when SSDs were sexy? That moment your very first SATA SSD loaded up Windows in what seemed like the blink of an eye. Your videos for viewing or editing hitting the screen mere moments after you clicked the mouse button. Game levels loading quicker than your mates so you get get in there first. What a blissful time.

And don't get me started on the wonders of the form factor. That little sliver of storage that hides away in your case without a single cable necessary. Just so nice. Apart from M.2 screws, which are now the most annoying little bastards of any new PC build. But at least the motherboard manufacturers are slowly introducing smarter ways to plug these things in.

Since then we've escalated the gains massively with PCIe SSDs, with each new generation coming close to doubling the speeds of the last. It's all so good we've become a bit passé about it all – which was the entire point. The hard drive was the last great PC bottleneck to be unplugged. We live in a new era of system responsiveness that's just so nice we take it for granted.

"Don't get me started on the wonders of the form factor. That little sliver of storage that hides away in your case without a single cable necessary. Just so nice. Apart from M.2 screws, which are now the most annoying little bastards of any new PC build."

Which brings us to now. We're right on the cusp of the newest PCIe Gen 5 SSD standard, which will once again double the performance. You'll need a new Ryzen 7000 or Intel Raptor Lake system to start thinking about those, but they're still super rare and pricey, so it's still a Gen 4 world, and that's just fine.

Perhaps you are planning a new build based on the new CPU platforms? It'll need an SSD or two. Maybe your current rig is running short on capacity – after all, it wasn't long ago that anything over 1TB was quite expensive. And there's the tragic possibility that you have a nice SSD for your OS and main apps, complimented by a hideously slow hard drive for mass storage that makes you cry a little inside every time you hear it groan into life and the agonising wait for something to happen.

So – upgrade! We've done the hard yards in the labs this issue, hauling in 14 SSDs so you know what's best for value and performance. Have a read, go invest a little bit of money, and enjoy the gains.

I hope the new year is off to a great start for you all, take care, readers.

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❶

ABELSSOFT TAGMAN

This music tool adds ID3 tags, renames MP3 files and rearranges the music collection.

Many files lack ID3 tags or have incomplete information, what makes it hard for the user to know the artist's name or song's title. Tagman 2020 uses specific servers to find these metadata in the internet. Even better: the software can also automatically detect and download the CD cover from the Internet. In this way Tagman checks all these information, therefore you will possess a personal and complete music collection. The program is also able to rename music automatically.

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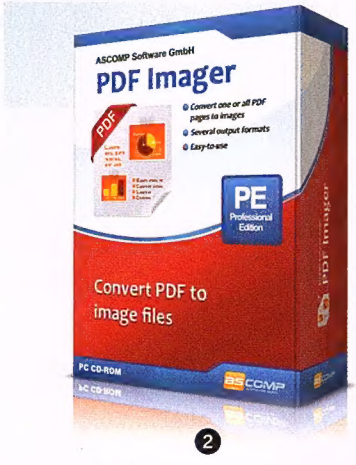

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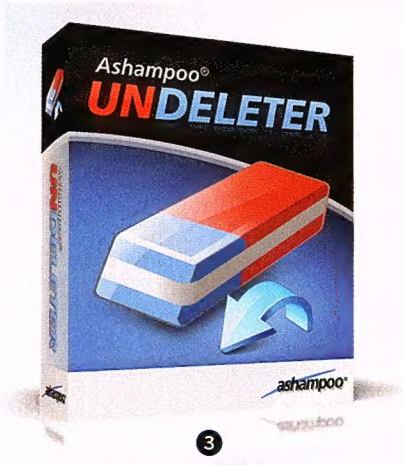

❸

ASHAMPOO UNDELETER

Never again trouble with accidentally deleted files.

If you accidentally deleted your favourite song from your PC, this isn't a disaster any more. Just use the effective search function of the Ashampoo Undeleter and have the program generate a list with all deleted files. In such a list even the condition of the files is displayed. This shows whether the files can be recovered completely, partly or not at all. Then you can recover your favourite song in your desired location with just one click. The recovery function of the Ashampoo Undeleter is extensive and not limited to the hard disk drives of your computer.

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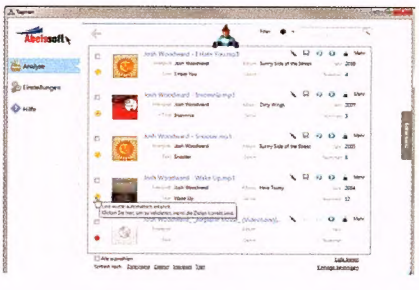

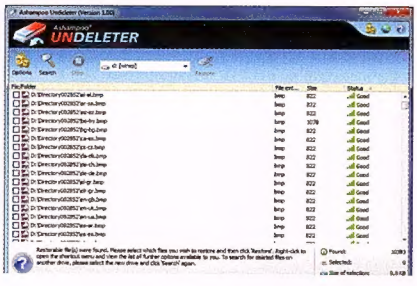

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HOW WE DO IT

Inside *APC*

Find out all about APC's editorial policies, test practices, how to read the benchmark results, and more.

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THE NEW WINDOWS 11
M.2 SSD GROUP TEST
14 DRIVES LABS TESTED
AVOID DRIVER DISASTERS

"Championing technology doesn't mean we're unrelenting yes-men and -women, however, and APC aims to be as objective as possible in all our coverage."

APC is Australia's oldest consumer technology magazine – having been consistently in print for over forty years, since our first issue way back in May 1980 – and we take that heritage and responsibility very seriously. While our focus is obviously on the personal computer the very definition of the PC has changed and shifted markedly since the early 1980s. As such, we touch on many other areas of tech, too, from smartphones and apps to peripherals, accessories, and beyond. We have two goals: to find the best modern tech and to help you make the most of it.

We're also an open church in terms of platforms. We know most people aren't wed to a single brand's products and use a variety of devices. And, like you, APC's journalists want to know what's good in tech – no matter what platform it resides on.

Independent reviews

Championing technology doesn't mean we're unrelenting yes-men and -women, however, and APC aims to be as objective as possible in all our coverage. That means identifying the best products from multiple perspectives – the best performance, best value and best features and, ideally, the products that offer the best mix of these three attributes.

As a matter of policy, reviews published in APC are not shared with product-makers prior to print. We will contact vendors under certain conditions; for example, if we have a problem testing a product that seems to indicate it may be faulty, or to invite a vendor to clarify how a particular feature works. If an APC reviewer has any potential conflicts of interest involving a brand, the review will always be assigned to another writer.

Labs testing

APC strives to conduct the most rigorous, objective scientific tests and benchmarks we can so as to make our reviews as unbiased as possible. We use a variety of tools and programs for this, including many freely available benchmark suites for assessing media encoding, general system performance including storage read and write speeds, gaming and battery life.

In most cases, for the benchmark results published in APC, you can assume that higher is better. There are certain tests that deviate from this rule where the opposite is true; in those cases, we've flagged the results with a note explaining as such.

We use both tables and graphs for displaying results; the latter offers better ease-of-readability, but tables are more compact, so we use these in most cases where thoroughness is preferred.

UPDATED FOR 2023

apc TESTBED

The current APC testbed used in the Labs for benchmarking all components. This testbed is updated as new and relevant technology comes on stream.

CPU	Intel Core i9 12900K
Motherboard	Asus Maximus Z690 Apex
Graphics Card	Nvidia GeForce RTX 4090 Founders Edition
RAM	2x16GB G.Skill Trident Z5 DDR5-6000
Power Supply	Corsair AX1000
Storage	Seagate Firecuda 530 2TB
Case	Thermaltake Core P8
Cooling	Cooler Master Flux PL360 AIO
Operating system	Windows 11 Pro 22H2

apc AWARDS

APC EDITOR'S CHOICE

When a product scores 4.5 out of 5, it carries the Editor's Choice Award. These are products that exceed expectations and deliver a quality experience up there with the very best.

APC HIGHLY RECOMMENDED

You will see this award if a reviewed product has scored four out of five stars. It means most people can expect satisfying performance from the product, and that we would use it ourselves.

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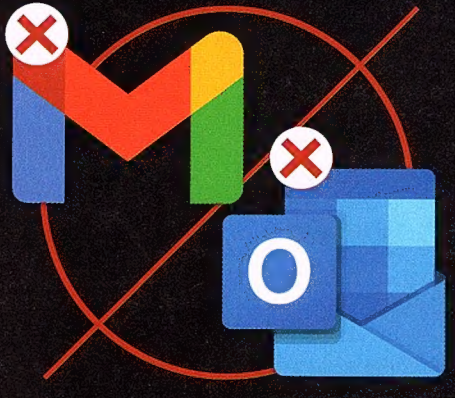

STOP USING GMAIL & OUTLOOK

Don't stick with a big-name webmail service just because Google and Microsoft want you to

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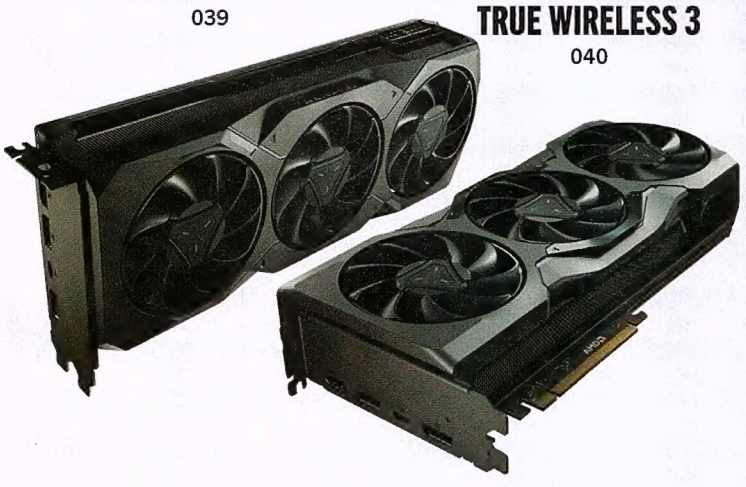

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NVIDIA KILLS OFF GAMESTREAM ON SHIELD

A huge blow to Nvidia Shield device owners.

Nvidia has decided to discontinue the GameStream feature for Shield devices. The company will push out an update to Shield devices starting mid-February, where GameStream will no longer be available.

If you're not acquainted with Nvidia's GameStream functionality, it's a feature that allows Shield TV or Shield tablet to stream games from a GeForce GTX-powered computer. The chipmaker had previously updated GameStream to support framerates up to 60 FPS at 4K (3840 x 2160) resolution.

Nvidia didn't share the reason why it's pulling the plug on GameStream. However, the chipmaker invited Shield users to give GeForce Now a try. GeForce Now is Nvidia's cloud streaming service, available free of charge if you're willing to live with significant limitations.

CHINA CLAMPS DOWN ON DEEPFAKES

New regulations target anything that might "belittle the reputation and honour of others."

Deepfakes are a problem. That has become clear over the years with people using artificially intelligent deep synthesis programs to scam, defame, and generally spread misinformation. China has made a step in tackling the issue of deepfakes with a new law that requires anything made with the use of deep synth tech to be tagged as such.

And it's not just facial replacement that's being targeted by the new regulations. It also relates to any kind of face manipulation, gesture manipulation, and anything involving deep learning, virtual reality, text/audio/image generation via synthetic algorithms, virtual scenes, and even anything generated using text-to-speech technology will need to be tagged as such. Honestly, it's a wonder deepfakes have been allowed to go unchecked in China for this long.

CPU

Intel launches 16 new 13th-Gen desktop CPUs

Higher power consumption, DDR4 support retained.

Intel announced 16 new Raptor Lake CPUs spanning its 65W mainstream PC chips and 35W "T-Series" categories. The new chips extend from the Core i3 to high-end Core i9 families and come with more cores and higher frequencies along with higher gen-on-gen pricing, mirroring the price increases we noticed with Intel's 12th-gen chips. They also have significantly increased peak power consumption compared to their predecessors.

Most of Intel's new 13th-gen processors announced today come with the same Raptor Cove architecture as the flagship models that launched last year, but some of the Core i5 and the lone Core i3 model reportedly come with the same die and architecture used for the 12th-Gen Alder Lake CPUs, albeit bulked up with more generous core counts and/or higher clock rates to enable higher levels of performance.

As we saw with the launch of the unlocked full-power K-series chips last year, Intel has also significantly dialled up its peak power consumption to keep the performance edge over AMD's competing Ryzen 7000 processors. So, while Intel's new chips slot into the traditional 35W and 65W envelopes that the company uses for its budget-geared lineup, they consume more power and will generate more heat than their predecessors.

New B760 motherboards will accompany the 65W Raptor Lake chips to market, but they don't bring many meaningful improvements over the prior-gen B660 lineup. Raptor Lake still maintains backward compatibility with existing 600-series motherboards, providing a value path that will mesh well with the lower-end processors (make sure you have the right BIOS).

Intel has also preserved support for DDR4 memory, a key cost-saving measure that gives the company a big advantage over AMD's pricey DDR5-only platforms, while also offering support for DDR5 memory. However, Intel has dropped peak DDR5 speeds down a notch on its lower-end models.

The Core i5 and i3 models all have a peak memory speed of DDR5-4800, lower than the DDR5-5600 supported by the pricier variants, and the same cache-per-core configurations as Alder Lake.

All 65W chips aren't 'officially' overclockable, but some motherboard vendors have developed workarounds that allow full overclocking on these models, which Intel has turned a blind eye to thus far.

INTEL 13TH GEN CORE SERIES (RAPTOR LAKE-S)

	Cores P+E/T	P-Core Base	P-Core Turbo	E-Core Base	E-Core Turbo	L3 Cache (MB)	IGP	Base W	Turbo W
i7-13700K	8+8/24	3400	5400	2500	4200	30	770	125	253
i7-13700KF	8+8/24	3400	5400	2500	4200	30	-	125	253
i7-13700	8+8/24	2100	5200	1500	4100	30	770	65	219
i7-13700F	8+8/24	2100	5200	1500	4100	30	-	65	219
i7-13700T	8+8/24	1400	4900	1000	3600	30	770	35	106
i5-13600K	6+8/20	3500	5100	2600	3900	24	770	125	181
i5-13600KF	6+8/20	3500	5100	2600	3900	24	-	125	181
i5-13600	6+8/20	2700	5000	2000	3700	24	770	65	154
i5-13600T	6+8/20	1800	4800	1300	3400	24	770	35	92
i5-13500	6+8/20	2500	4800	1800	3500	24	770	65	154
i5-13500T	6+8/20	1600	4600	1200	3200	24	770	35	92
i5-13400	6+4/16	2500	4600	1800	3300	20	770	65	148
i5-13400F	6+4/16	2500	4600	1800	3300	20	-	65	148
i5-13400T	6+4/16	1300	4400	1000	3000	20	730	35	82
i3-13100	4+0/8	3400	4500	-	-	12	730	60	89
i3-13100F	4+0/8	3400	4500	-	-	12	-	58	89
i3-13100T	4+0/8	2500	4200	-	-	12	730	35	69
i5-13500	6+8/20	2500	4800	1800	3500	24	770	65	154
i5-13500T	6+8/20	1600	4600	1200	3200	24	770	35	92
i5-13400	6+4/16	2500	4600	1800	3300	20	770	65	148
i5-13400F	6+4/16	2500	4600	1800	3300	20	-	65	148
i5-13400T	6+4/16	1300	4400	1000	3000	20	730	35	82
i3-13100	4+0/8	3400	4500	-	-	12	730	60	89
i3-13100F	4+0/8	3400	4500	-	-	12	-	58	89
i3-13100T	4+0/8	2500	4200	-	-	12	730	35	69

© AMD

Radeon RX 7900 XTX too hot?

Defective vapour chamber may be causing overheating.

Overclocking extraordinaire Roman "der8auer" Hartung has potentially found that AMD's RDNA 3 flagship may have a defective vapour chamber. Hartung believes that the vapour chamber may have a defect, whether it be a design problem or an issue with the choice of materials used in its fabrication. It would appear that the liquid inside the vapour chamber is facing circulation problems after condensation. The root of the problem could be inadequate pressure or a liquid deficiency inside the vapour chamber.

> "Hartung believes that the vapour chamber may have a defect, whether it be a design problem or an issue with the choice of materials used in its fabrication."

AMD has released an official statement regarding the user reports of Radeon RX 7900 XTX graphics cards. In a nutshell, the chipmaker urges affected consumers to contact support. "We are aware that a limited number of users are experiencing unexpected thermal throttling on AMD Radeon RX 7900 XTX graphics cards (reference models made by AMD). Users experiencing unexpected thermal throttling of an AMD Radeon RX 7900 XTX should contact AMD Support."

So far, only MBA (made By AMD) models appear to suffer from overheating. The reference design exhibited hotspots peaking up to 110 degrees Celsius; user feedback claims that the RDNA 3 graphics card shows this behaviour even with the cooling fans at full throttle.

AMD UNVEILS THREE RYZEN 7000X3D V-CACHE CHIPS

7950X3D, 7900X3D & 7800X3D, three new 65W non-X CPUs, too.

AMD announced six new Zen 4 Ryzen 7000 processors for its AM5 platform at CES 2023, with three new high-end Ryzen 7000X3D processors leading the charge with the company's revolutionary 3D V-Cache in chips that top out at an incredible 5.7 GHz.

The new high-performance AMD chips come in 8-, 16- and 24-core flavors, significantly expanding the lineup of 3D V-Cache chips over the single Ryzen 7 5800X3D model that arrived with the first-gen chips. AMD claims explosive generational performance gains with these new chips, saying they will beat Intel's fastest gaming chip by up to 24 percent in some games.

AMD also announced three new 65W Ryzen 7000 "non-X" models that span the Ryzen 5 to Ryzen 9 families, thus providing a new lower level of entry to the AM5 platform to address some of the pricing issues associated with the company's new AM5 platform.

© Nvidia

GTX 1650 NOW THE MOST POPULAR

The GTX 1060's time at the top has come to an end.

There's a new top graphics card on the Steam charts these days. Unsurprisingly, it's not the massively power-hungry and expensive RTX 4080. It's Nvidia's GTX 1650 that has overtaken the GTX 1060, which was in the top spot for years.

According to Steam's November hardware survey, usage for the GTX 1650 went up to 6.27 percent, whereas the GTX 1060 fell to 5.77 percent, a nearly two percent drop off from October.

That is a somewhat suspiciously large drop-off for the GTX 1060, though. Perhaps something changed in how Steam was recording user rigs, or how it collects data. The hardware survey is just that, a survey – users have to opt in to be counted – so changes in how the survey is run could affect results.

© The Tonight Show

PARIS HILTON AND JIMMY FALLON SUED FOR PROMOTING NFTs

Is the Bored Ape Yacht Club sinking?

Fallon, Hilton, and others who have used their celebrity to promote NFTs are facing a proposed class action lawsuit accusing them of fraud. "The truth is that the Company's entire business model relies on using insidious marketing and promotional activities from A-list celebrities that are highly compensated (without disclosing such), to increase demand" the lawsuit states.

The lawsuit alleges that all of the Bored Apes action over the past year was in fact "a vast scheme" between Yuga Labs, "a highly-connected Hollywood talent agent" named Guy Oseary, and MoonPay, a company that "purports to be a white-glove service designed to help the super-rich and celebrities buy NFTs" but is in fact, according to the lawsuit, "a covert way to compensate the promoter defendants" without disclosing it to investors. ■

3D enters a new dimension (sorry...), with Asus resurrecting the tech in upcoming laptops.

© ASUS

INNOVATION

Best of CES 2023

The annual unveiling of new tech and toys did not disappoint.

The Consumer Electronics Show (CES) took place in Las Vegas right after New Year's, and is where all the big companies announced breakthrough products. While TVs, cars, and smaller gadgets get a lot of attention, it's also where HP, Dell, Lenovo, Intel, AMD, Nvidia, and even Microsoft reveal what is hitting store shelves later this year.

New PCs, new form factors, updated processors, some whacky concept devices (usually from Razer), and more can be expected. Here are some of the highlights that have us excited.

Asus glasses-free 3D OLED display

Thought 3D was dead? Think again. Asus has debuted its most impressive new tech of CES 2023 in the form of the first glasses-free 3D panel found on a laptop. The all-new ProArt StudioBook 16 and VivoBook Pro 16X have the new displays onboard, something Asus is calling "Spatial Vision."

There are two parts to Asus Spatial Vision. The first is that this is a high-quality OLED display. It has a 3.2K resolution and a 120Hz refresh rate. So even if you're just using it in regular old 2D mode, it's really good.

The other is the eye tracking technology. Paired with a lenticular lens, the display is capable of producing a defined image for each eye creating an autostereoscopic 3D image. Because it tracks your eyes, as they shift around, the image responds. So there's no requirement to stay looking exactly straight at the display like you're having a staring contest with it.

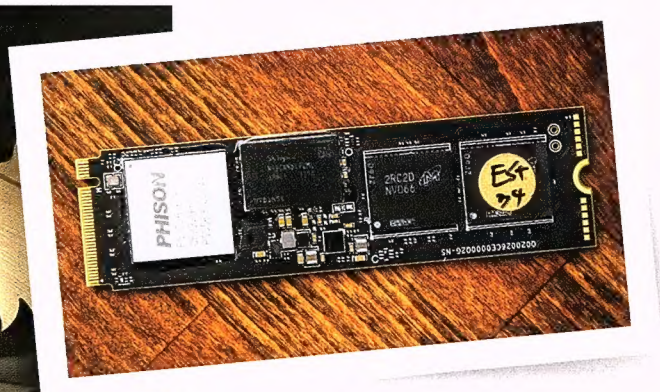
Thermaltake's magnetic fans let you swap blades

Available in February, the 120mm Swafan EX12 and 140mm EX14 fans snap together magnetically so you only need to run a single cable from your RGB controller or motherboard to control all three. The Swafans have another trick up their sleeves: they come with two sets of blades for each fan: a regular blade and a reverse fan blade. So, if you want to change the airflow direction of a fan, all you need to do is pop out its blade and replace it with the opposite kind.

First PCIe 5.0 SSD tested: yes, it's fast

We've been waiting what seems like forever for someone to finally come out with a PCIe 5.0 SSD that consumers can buy. While we still don't have a shipping drive, Phison is

Thermaltake's magnetic fan blades can be detached and replaced with spinners blowing in the opposite direction.



Finally we see and actually test a PCIe 5 SSD! Initial performance is good, but PCIe 3 and 4 will be storage staples for another couple of years.

Share traders and sim racers rejoice, Samsung's immensely huge 57-inch OLED is coming.

showing off its E26 controller, which is going to power SSDs from a lot of OEMs very soon. We looked at an engineering sample of an SSD with a Phison E26 controller inside and were able to run an extensive array of tests.

We tested a 2TB sample which blew away all of the leading PCIe 4.0 drives, including the Samsung 990 Pro on most becnhmarks. In 3DMark's SSD performance test for gaming, the E26 sample scored 5,443 to the 990 Pro's mark of 4,816. However, results were more muted at the all-important size of 4K QD 1 for reads and writes, where Phison's sample SSD was actually a few microseconds behind the 990 Pro.

This 55-inch, OLED TV is totally wireless including the power

At APC we don't normally talk much about TVs, unless we're using them as monitors. However, at the CES Unveiled press event, we saw Displace TV, a truly unique display that gets its power from batteries, its video from a Wi-Fi 6E base station and its controls from hand gestures.

The 55-inch OLED display gets its power from four hot-swappable batteries. The company claims that the batteries will last about a month on a charge if you watch TV for around six hours per day. Because the batteries are hot-swappable, you can charge one while the system runs on the others.

Displace says that the TV will "magically stick" to your walls using its "proprietary active-loop vacuum technology," which only requires a light push and no brackets or screws at all. This sounds like a high-tech suction cup and we are skeptical, and we didn't see it mounted during the demo.

Nvidia tech uses A.I. to upscale video to 4K

One of Nvidia's more interesting CES 2023 announcements involves a technology it calls RTX Video Super Resolution, which can take a video from YouTube, Netflix or another streaming service and convert it from 1080p to 4K or 720p to 2K. Due in February, the feature will require RTX 3000 or 4000 series GPUs, at least at first, and will be automatically triggered by Nvidia's GeForce Experience software, though it will run on videos streamed through either Chrome or Edge browser.

Nvidia's Eye Contact feature is creepy, but it works

One constant problem with video conferencing: You want your call partners to think that you're looking straight at them, but you're actually gazing at a window on your desktop rather than straight into the webcam. Nvidia has a solution which it calls "Eye Contact." Simply put, the software uses A.I. to modify the image of your eyeballs so that it always looks like you are starting straight ahead. Because Nvidia Broadcast serves as a virtual webcam driver, you will be able to use the feature in any video conferencing or recording software you want.

Samsung's 57-inch 8K Mini-LED, 49-inch OLED Neo gaming monitors

Samsung impressed us with the debut of two new monitors aimed at the gaming crowd: the 57-inch Odyssey Neo G9 and the 49-inch Odyssey OLED G9. Both monitors are sure to set gamer tongues wagging, but the former goes bonkers regarding specs.

The enormous 57-inch panel features a Dual UHD resolution, meaning it's the equivalent of two 4K monitors sitting side-by-side. Combined with a 1000R curve, the latest Odyssey Neo G9 provides a resolution of 7680 x 2160 with an aspect ratio of 32:9.

Razer & Alienware capitalise on big-screen gaming laptop trend

Big-screen gaming laptops are all the rage at CES 2023. After Dell announced its latest Alienware gaming notebook with a massive 18-inch display, Razer is teasing its own Blade 18, setting up the stage for large-format gaming laptops to be the trend for this year.

In addition to the Razer Blade 18, Razer also teased a Razer Blade 16, which will come with a 16-inch display. It's unclear if the new models will replace the Razer Blade 17 and Razer Blade 15, or if these larger displays will slot in alongside Razer's existing notebooks, giving gamers more variety and choice on screen sizes and resolutions. ■

Nvidia's Video Super Resolution leverages the company's upscaling expertise.

18-inch gaming laptops are apparentluy the new big thing for 2023.

© Amazon

TECH BRIEF

Intel charts course to trillion-transistor chips

2D transistor materials, 3D packaging research.

Intel released nine research papers at IEDM 2022 that lay the groundwork for future chip designs, as the company looks to deliver on its promise of developing processors with over a trillion transistors by 2030.

The research includes new 2D materials for transistors, new 3D packaging technology that narrows the performance and power gap between chiplet and single-die processors to a nearly-imperceptible range, transistors that 'don't forget' when power is removed, and embedded memories that can be stacked directly on top of transistors and store more than one bit per cell, among other innovations.

Intel's Components Research (CR) Group lays the initial groundwork for the company's future technologies, but not all of these initiatives will result in products that ship to market. Those that do come to market would typically arrive in five to ten years.

The pace of transistor density increases continues roughly in line with Moore's Law, but the economics of today's chips are not improving at the same pace – the price per transistor is rising as we move to denser nodes. In addition, poor scaling of some chip elements, like analog and caches, complicates matters further. As such, the industry is moving en masse to chiplet-based designs for high-performance chips.

The overriding goal of any chiplet-based design is to preserve the best attributes of the power consumption and performance (latency, bandwidth) of the data pathways inside of a single-die monolithic processor while tapping the economic benefits of using a chiplet-based approach, like increased yield from smaller dies fabbed on a leading-edge process and the ability to use older, cheaper nodes for some of the other functions that see lesser density improvements.

As such, the battleground for semiconductor supremacy is shifting from the speed of the transistors to the performance of the interconnects, with new technologies like silicon interposers (EMIB) and hybrid bonding techniques coming to the forefront to improve economics.

However, these approaches still result in inevitable performance, power, and cost tradeoffs, which Intel's new 'Quasi-Monolithic Chips' (QMC) 3D packaging tech looks to solve. As the name implies, Intel's QMC aims to offer nearly the same characteristics as the interconnects that are built right into a single die.

QMC is a new hybrid bonding technique that features sub-3 micron pitches and results in a 10X increase in power efficiency and performance density over the research Intel submitted at last year's IEDM. That previous paper covered an approach with 10-micron pitches, which was already a 10X improvement. As such, Intel has found a pathway to a 100X improvement in just a few years, showing that the company's work in hybrid bonding is accelerating rapidly. QMC also enables multiple chiplets to be stacked vertically atop one another, as seen in the graphic below.

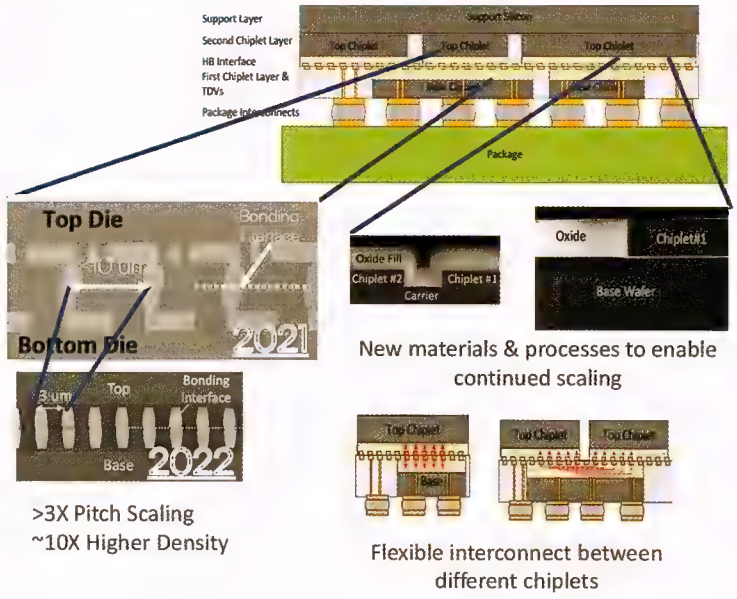
Intel's process roadmap already dips below the nanometer scale to the Angstrom scale, and even though the node naming conventions have long ago lost their relation to actual physical measurements of the transistors, it is clear that a radical new approach will be needed for continued scaling. Most of the industry is betting on a shift to 2D atomic channels in the future, but as with all new tech, there will be many steps to such a radical change.

Paul Alcorn ■

The next 10x improvement in interconnect density

Introducing Quasi-Monolithic Chips for Next-Generation 3D Packaging

- New materials & processes to blur the line between packaging and silicon processing
- Continue hybrid bonding scaling to 3 um pitch/10X higher density compared to 2021 publication
- Enable maximum flexibility for top & bottom chiplets sizes & relative locations and addresses power & signal integrity challenges of typical through-silicon vias



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END USER

Make stuff that lasts a long time, tech companies

Upgrading doesn't feel as good when you've been conditioned to expect flimsy gear, writes Shaun Prescott.

Shaun is an Australian editor for *PC Gamer*, *GamesRadar* and *PLAY*, and writes for *APC*, *TechRadar* and more.

During the recent Black Friday sales I bought a nifty laptop for a ridiculous price. It was the second generation Lenovo ThinkBook 16p, and considering its specs, it's amazing that I paid only $1,500 for it: RTX 3060, Ryzen 5 CPU, and a sumptuous 16 inch screen. I was in need of a new laptop, but had been waiting for a good deal to come along. That sale price still hasn't been beaten, but was probably prompted by the arrival of the third generation of the 16p.

Despite getting it for well over 50 percent off, I spent a lot of time reading reviews. Over the years, and having churned through quite a few laptops, I'm still surprised how rare it is to find a laptop review – or any technology review – that takes in the device's long term hardiness. My previous work laptop was a very highly regarded model by a very well-known brand, and while I was happy with it for about six months or so, the problems set in quickly after that. That's an understatement: the laptop started to literally fall apart. Thankfully it was still covered under warranty back then, but the battery dying after 18 months wasn't. Nor was I under warranty when the trackpad suddenly and mysteriously died.

Maybe it's just a problem inherent to laptops: the things die quickly. Usually, one's first taste of sour disappointment comes with a deteriorating battery. I use my laptop for over 12 hours a day during weekdays, so maybe it's because I'm a power user, but the battery in every PC laptop I've owned has died before the two year mark. I can't stand using Macs, but the one time I did enter that ecosystem, the battery lasted over three years.

> "I don't want to turn this column into a collection of petty consumerist gripes, but since I've already started down this road, I might as well keep going."

I don't want to turn this column into a collection of petty consumerist gripes, but since I've already started down this road, I might as well keep going. The longevity of most tech products in 2023 is frankly unacceptable. For some of the best examples going, look no further than the videogame industry. Nintendo has faced lawsuits due to the famous dodginess of the Switch console's Joy-Con sticks, but it's actually a problem that blights most modern controllers. I've been through two Dualsense controllers since the PS5 launched in late 2020: the left stick drifted on one, and a spring eroded in the other. I fixed the stick drift on the former, but then, exactly a week later, the right stick started to drift.

Luckily, Sony released the Dualsense Edge controller this month, which lets you replace those famously-prone-to-breaking analog sticks. The catch? It's $339, and those stick replacements are $34. The cynic in me can't help but feel that the Dualsense Edge is a tacit acknowledgment of the base model's failings, but rather than fix that, Sony is releasing a premium model (for the record, my main Dualshock 4 controller has lasted nearly a decade).

It shouldn't be too much to ask: make stuff that will last for longer than a couple of years. Nowadays, buying an expensive piece of tech just makes me paranoid about how soon it's going to break. I've no reason to believe the 16p will – this will be the first Lenovo product I've ever owned – but aside from the blatant disrespect shown to customers when a product proves a bit on the flimsy side, it's also a costly environmental concern.

Is Musk's vision for social media revolutionary or reductionist?

How watching Musk's twitter regulation missteps in real time shows how complicated and critical the balance of content moderation will be for the future of social media.

Whether it's the blanket banning of telcos to stop bots (and tens of thousands of legitimate Twitter users), or the reinstatement of Ye (formerly Kanye West); both of which were decisions that were almost immediately backpedalled, it's clear that many of Chief Twit Elon Musk's silver bullet solutions to content moderation are not nuanced enough to tackle what will undoubtedly be one of the biggest challenges of the 21st century: How to create a social media platform that facilitates freedom of expression without amplifying the darker parts of humanity.

Musk's streamlined approach to Twitter's management since taking the reins in October has been controversial, to say the least. With giant portions of the company being cut for not wanting to adopt Musk's 'hardcore' work ethic and the reinstatement of a range of accounts of self-described misogynists, racists and anti-LGBQT advocates, it's not exactly been a management style that is attempting to please everyone. So it's hardly surprising that the changes have stoked widespread opposition to the new direction.

For others, the liberalisation of Twitter over the last months of 2022 was more like adding fuel to a giant social experiment which burned brighter than anything the platform had seen in months. This camp isn't exclusively Accelerationists with popcorn and front row seats to Twitter's implosion however, including former CEO Jack Dorsey, who admitted recently in an online blog that he lost control of Twitter's moderation policies in 2020 and seems to hold an almost identical perspective to Musk when it comes to how the company should manage content moving forward.

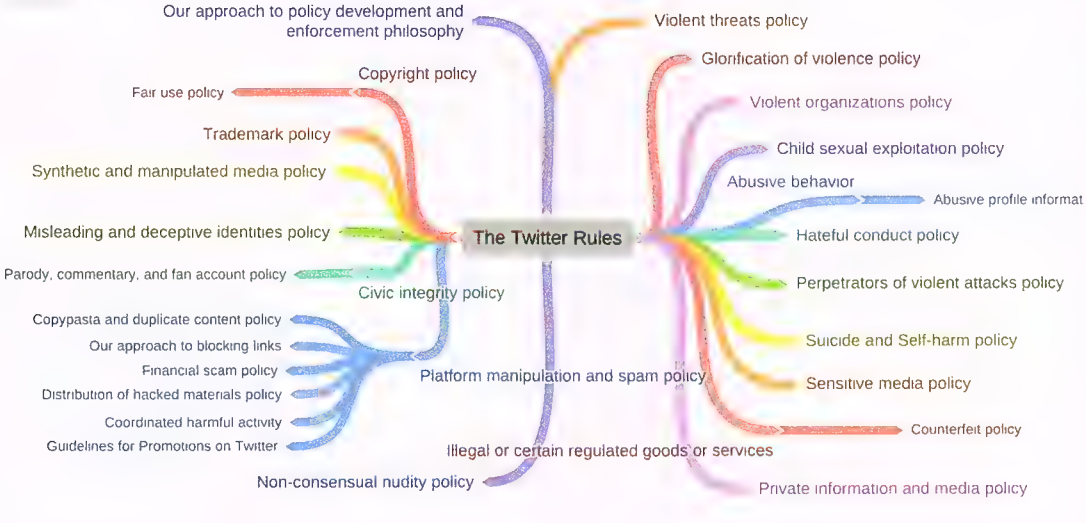
On the 19th of November Musk Tweeted " New Twitter policy is freedom of speech, not freedom of reach." Explaining further that Twitter would abstain from taking down posts wherever possible, opting to instead de-prioritise offensive material so it could only be found if sought out. This position aligns pretty closely with the last key points of Dorsey's social media manifesto blog post which proclaims:

1. Social media must be resilient to corporate and government control.
2. Only the original author may remove content they produce.
3. Moderation is best implemented by algorithmic choice.

Both Musk and Dorsey are, presumably, talking exclusively here about posts that convey genuinely held beliefs or opinions by real people that are not criminal, sexually explicit or violent as that content contravenes the company's existing set of less contested content moderation policies, but what the two are, and are not, saying is exactly what's up for debate here. The changes so far concern the Sensitive Media Policy, updated in October, a 1,500 word policy that's about as detailed as what the average billionaire might be able to rattle off in an hour sitting. Many within the company during the transition of power felt that Musk's approach had the potential to unwind 15 years of content policy refinement, according to a New York Times report, putting the company back in the social media dark ages.

If you take Musk's linking to a certified Fake News outlet to rebut Hillary Clinton and his use of Twitter safety content policies to ban a Twitter account that tracked the movements of his private jet, then you might be inclined to agree with these concerned former Twitter employees.

Joel is one of the senior journalists on *APC* magazine and apart from being the resident laptop, monitor and fitness tech geek, he's also pretty into surfing his local Sydney beach breaks when he's not in front of a screen.


Our approach to policy development and enforcement philosophy
Violent threats policy
Glorification of violence policy
Copyright policy
Fair use policy
Violent organizations policy
Trademark policy
Child sexual exploitation policy
Synthetic and manipulated media policy
Abusive behavior
Abusive profile informat
Misleading and deceptive identities policy
The Twitter Rules
Hateful conduct policy
Parody, commentary, and fan account policy
Perpetrators of violent attacks policy
Civic integrity policy
Copypasta and duplicate content policy
Suicide and Self-harm policy
Our approach to blocking links
Financial scam policy
Platform manipulation and spam policy
Sensitive media policy
Distribution of hacked materials policy
Coordinated harmful activity
Counterfeit policy
Guidelines for Promotions on Twitter
Illegal or certain regulated goods or services
Non-consensual nudity policy
Private information and media policy

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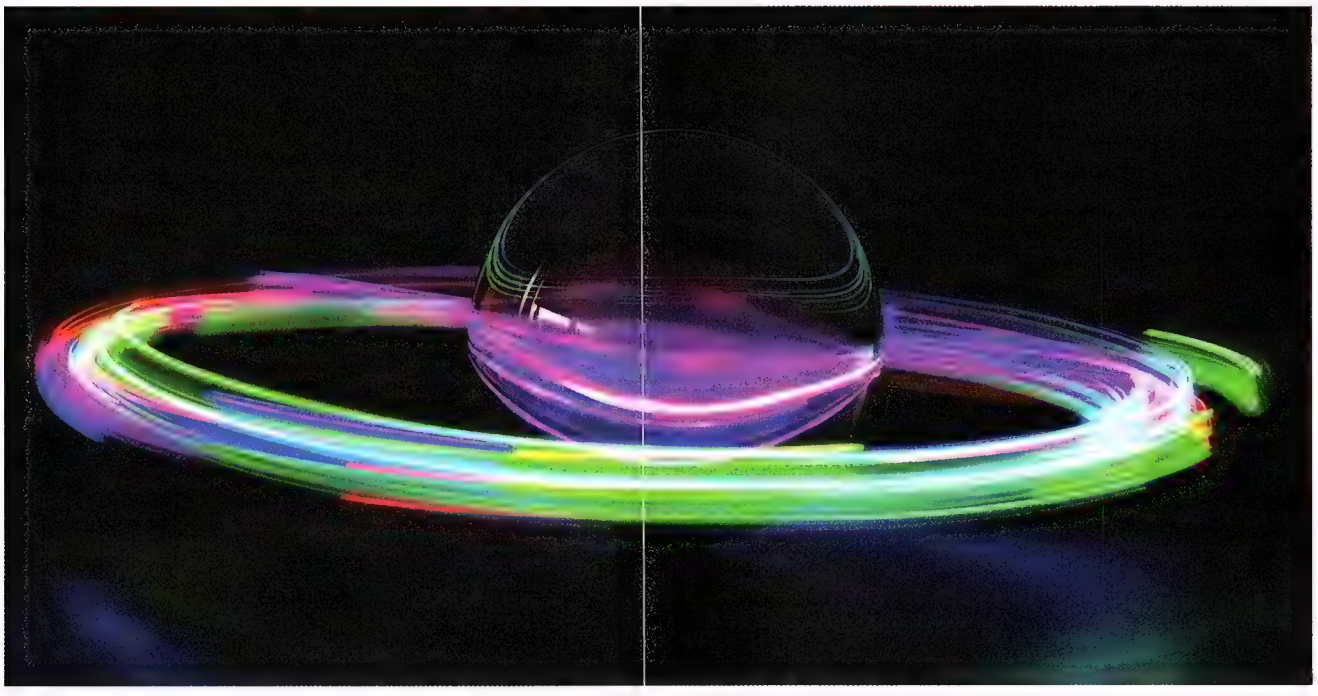
TWO BITS

The year ahead

A peek into the crystal ball.



Chris has been elbow deep in PCs since before the turn of the millennium, and he wouldn't have it any other way.

The PC industry is under pressure. Following the work-from-home pandemic boom, supply chain issues and the GPU mining craze, the market is on a downward trend. Of course, we've had the launch of Intel 13th Gen and AMD's Ryzen 7000 platforms, plus Nvidia's RTX-40 series and AMD's RX 7000 series of graphics cards. What's to come in 2023?

Firstly, almost all of those products are expensive, particularly the graphics cards. To most, the idea of spending over $1,000 on a graphics card is ridiculous, let alone over $2,000. But, unlike those high-end releases, the 2023 GPU market will be dominated by more affordable options. Performance depending, sales of cards like the RTX 4060 and 4050 will drive the market, along with AMD's competing RX 7700 and 7600 alternatives. That's where the real market battle between AMD and Nvidia will be waged.

On the CPU and motherboard side, CES saw the launch of lots of affordable options, including 65W 13th Gen and AMD non-X models. Pairing these with Intel B760 or AMD B650 motherboards will deliver excellent performance and bang for your buck. They don't require investment in an expensive cooler either. Personally, I'm really looking forward to Intel's i5-13400. It could end up being one of the best price/performance CPUs ever. If you're upgrading a system from a few years ago, expect a big increase in both multi-threaded and single threaded performance.

On the memory side, DDR5 prices are dropping rapidly, and AMD will be thankful for that given Ryzen 7000 dropped DDR4 support. Price parity isn't far away. The only reason to buy an Intel DDR4 motherboard over a DDR5 one is if you already have a good high end DDR4 kit.

PCIe 5.0 SSDs are yet to appear, and that's a bit of an odd one given both AMD and Intel offer support for them. Are they too hot? Do they offer any tangible performance gains? I'd put a bet on yes for the former and no for the latter. A good PCIe 4.0 drive (or even PCIe 3.0) will remain highly capable for years to come. And the humble hard drive isn't going anywhere either. Large capacity SSDs are still too expensive per GB for most users.

The real question is whether upcoming mainstream PC hardware will offer compelling reasons to upgrade. Convincing those on a budget to upgrade in a time of economic uncertainty is going to be a tough ask. The PC industry is surely going to suffer some pain in 2023 as people allocate money towards essential things like increasing mortgages, rent, food and utility prices, and away from discretionary purchases.

Looking at the macro picture, the war in Ukraine looks like it won't be ending anytime soon. That means continuing high energy and logistics costs. The cost of the most advanced sub-5nm nodes is increasing. Moore's Law is on its last legs. I believe TSMC's chip manufacturing dominance will wane. Intel has dropped billions in capital on its manufacturing with help from the US government. It's clear there's the possibility of a shakeup, but what form will it take?

2023 might not be the year it happens, but I believe ARM will inevitably encroach into the desktop market. There are billions of devices already, the expertise is there and power efficiency cannot continue to be ignored.

2023 is the year of the mainstream. Deservedly so. ■

Chris Szewczyk

© Getty

Less is more

Understanding power and efficiency.

Nvidia's RTX 4090 can use up to 450W of power, but could be more efficient with a lower power limit.

Creating a modern microprocessor involves myriad decisions, including size and transistor counts, but even with a finalised design, there are still a few knobs that can be used for further tuning: voltage and frequency. These tools are often available to end users and lie at the heart of overclocking. As the saying goes, with great power comes great responsibility.

I mean that literally in this case. Power increases directly in proportion with frequency and with the square of the voltage. That's why higher clock speeds require more power, but if you also need more voltage to stabilise those higher clocks, you get a double whammy. The reverse is also true, naturally – drop the voltage and/or frequency and you can reduce power requirements.

> "Cranked up to a 133 percent power limit and with higher GPU and memory clocks, the RTX 4090 Founders Edition performance improved by a whopping... 3 percent."

There's been a lot of noise about the maximum 450W power rating of the RTX 4090 reference design, with custom cards potentially drawing 500W or more. Meanwhile, the RTX 4080 curtails power use, with a limit of 320W by default. But while both cards hit their power limits in some games, there are also plenty of situations where they don't need as much power – and we can manually set a lower power limit to greatly boost the overall GPU efficiency.

What happens to performance and power use with tighter limits? I took an RTX 4090 Founders Edition and ran tests on eight demanding ray tracing games at 4K and maxed out settings. I chose ray-tracing titles because they tend to be more power-hungry than traditional games. *Forza Horizon 5*, for example, used around 310W at 4K Extreme. I repeated those tests with a power limit of 90, 80, 70, 60, and 50 percent.

The more power a game used at the default 100 percent setting, the more the impact of a lower power limit became. That makes sense, but across all the power limits, power use decreased faster than frame rates – or in other words, the RTX 4090 become more efficient. The sweet spot seems to be around the 70 percent mark, at which point the average power use dropped by 22.6 percent while performance only fell by 5.2 percent.

Using eight games in aggregate hides the impact of outliers that might become more common over the coming years, so let's also look at the extremes. The worst-case result was *Metro Exodus Enhanced Edition*, where performance at the 70 percent power limit decreased by 8.2 percent. That's noticeable outside of running benchmarks, but power use was still 27.7 percent lower. The best-case result was in *Minecraft*, which only used 380W at default, so lowering the power limit was less impactful. Its power use still fell by 17.9 percent with the 70 percent limit in place, while performance hardly changed at all with a 3.4 percent dip.

However, overclocking naturally shows different results. Cranked up to a 133 percent power limit and with higher GPU and memory clocks, the RTX 4090 Founders Edition performance improved by a whopping... 3 percent. Power use, on the other hand, jumped up by 16.8 percent, averaging 474W across the test suite compared to 406W at stock – with a worst-case power draw of 515W.

I talked about the early news of melting 4090 power adapters last month, and Nvidia's official response is that it's extremely rare and mostly down down to loose power cables. Overclocking certainly won't help matters, but reducing power draw through the 16-pin adapter can't hurt. If you happen to have an RTX 4090, giving up performance to improve efficiency really isn't a bad idea.

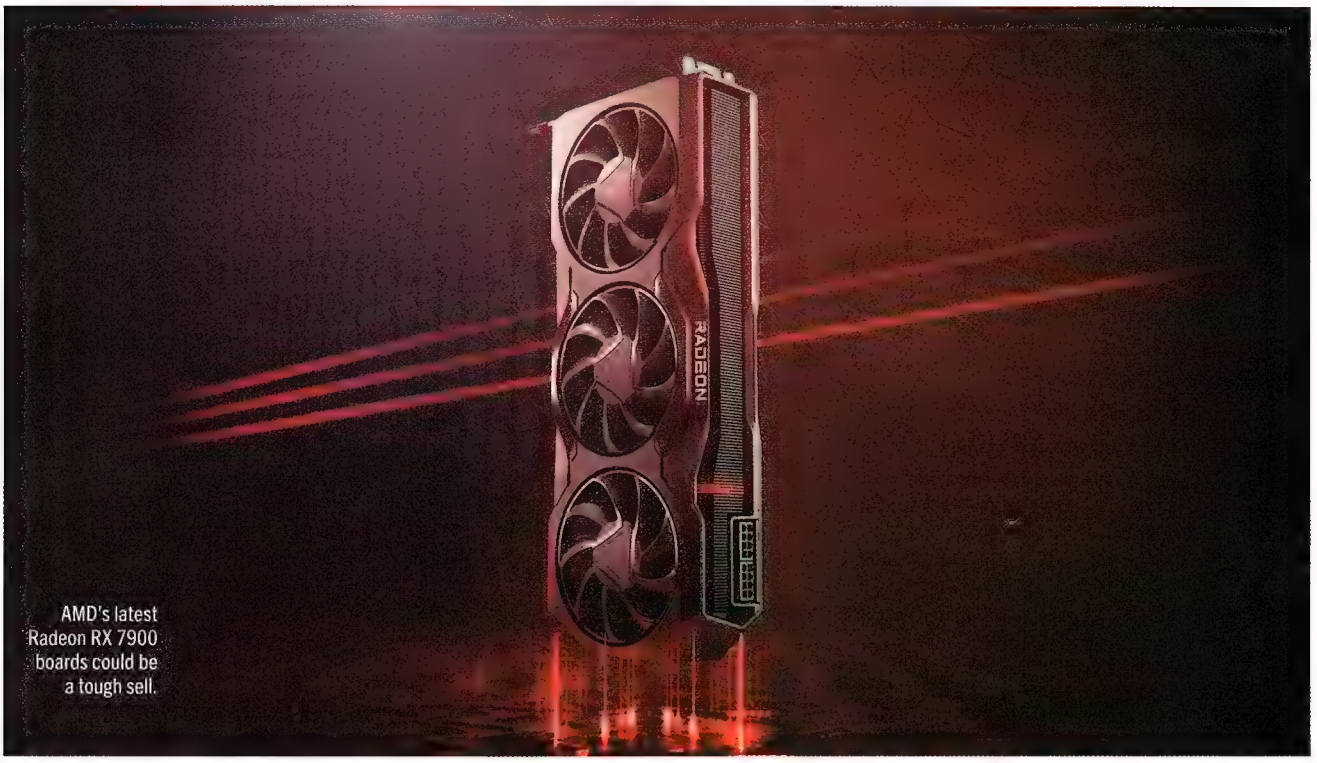
Jarrod Walton ■

Jarrod Walton
Jarrod can barely contain his excitement with all these big launches.

TRADE CHAT

The GPU pricing paradox

Why graphics card sales have stalled.



AMD's latest Radeon RX 7900 boards could be a tough sell.

Jeremy Laird
Six raw 4K panels forbreakfast, laced with extract of x86... Jeremy Laird eats and breathes PC technology.

Something odd is going on in the PC graphics market. Nvidia and AMD have launched their latest GPUs, but they seem priced to fail. I'm not talking about the $2,959 Nvidia GeForce RTX 4090. No, it's every other graphics card launched by the dynamic duo that's the problem.

In case you've been living under a rock, that's the Nvidia GeForce RTX 4080 16GB, and the AMD Radeon RX 7900 XT and 7900 XTX. The GeForce card is priced at $1,659, while the AMD boards are $1,619 and $1,789 respectively. Of course, those are RRPs, rather than real-world street prices.

Recent history has seen prices of pretty much all GPUs outstrip any RRP. Indeed, I recently saw an Nvidia GeForce RTX 3080 from the previous generation priced at $1,199 for the first time. So, it's taken two years from launch to see the inflated price of the RTX 3080 fall back to almost-RRP ($1,139). Incredible.

With that in mind, the crazy high prices of those new GPUs makes superficial sense. Over the last couple of years, gamers have been willing to spend megabucks on graphics. The genie is out of the bottle – $2,600 (street price) for a second-tier GPU like the RTX 4080 is the new reality. And the only reason why AMD's boards top out at $1,819 is that the new 7900 simply can't compete at the high end.

The good news is that there's every reason to think it's wrong. While gamers have proved willing to pay extortionate prices over the past two years, it doesn't automatically follow that they'll continue to do so. Market conditions of late have been little short of freaky, what with a huge spike in demand thanks to ethereum mining and the influence of a global pandemic.

Both of those factors have now essentially evaporated. Of course, some lingering pandemic-related supply constraints still prevail. And it's unlikely that we've heard the last of crypto-fueled demand for graphics cards. But the majority of the upward price pressure provided by those exceptional externalities has vanished.

In the meantime, both AMD and Nvidia have cranked out a huge number of those previous-gen GPUs. Many are as yet unsold and far more again are being unleashed onto the used market as the whole crypto thing unwinds following the great ethereum merge and the currency's shift from proof of work to proof of stake.

As a consequence, this year has seen GPU prices tumble dramatically. That talismanic RTX 3080 is getting on for one-third of the price it was at the beginning of the year, with prices still falling. At the same time, widespread reports of the RTX 4080 selling poorly have emerged. For sure, the RTX 4080 did not rapidly sell out after launch, something that had become the norm in recent years.

Of course, retailers can't immediately slash prices on the RTX 4080s they already have in stock to get the cards shifted as they'd be making big losses. So, it will take a while for pricing to reflect the reality of much lower demand. But that is the reality. Demand for GPUs is a fraction of what it was when gamers were paying megabucks. Eventually, that will be reflected in prices.

Jeremy Laird ■

Scamming the scammers

If Jon Honeyball is almost falling for internet scams then we should all be on high alert.

© Getty

Internet scammers are becoming increasingly sneaky. In the past, I grew used to regular phone calls claiming to be from Microsoft, or some equivalent organisation. They would tell me, in a very stern voice, that my computer was infected with viruses and that they were calling from Microsoft technical support. And that I needed to follow their instructions to remove this malware. Immediately.

At first, it was just easier to hang up the call. But when this happened for the fourth time one morning, I decided it was time to switch tactics and waste as much of their time as possible. I would respond with an appropriate, "Oh no, I did wonder why things were going so slow" and generally play along with their script. The goal was to get to 30 minutes, at which point I would usually just hang up.

But yesterday, I nearly fell for a scam. The email came to the lab email address claiming to be from PayPal. It said that "Billing Department of paypal sent you an estimate for $550.00." The poor English would normally be enough to activate my Delete button, but the email header of "service@paypal.com" was correct. And, digging into the details, the mail routing came from PayPal itself. Intrigued, I decided to phone the number on this message, and got through to a typical call centre. I explained the problem, and it was only when they asked for my username on PayPal and my password that the rat smell went from background odour to repugnant whiff. I hung up.

I went back to the paypal.com main site, logged into my account, and of course found no trace of this attempted transaction. And the support phone number on the paypal.com site was different. So I phoned that one instead. It appears that it is possible for PayPal users to generate estimates within the PayPal site, and issue them to random email addresses. And the PayPal representative I spoke to said there is nothing PayPal can do about this. Which is somewhat troubling, if true (we did ask PayPal for a comment, but silence came the stern reply).

It was almost enough to bring me out of scam-baiting retirement, to join the likes of "Scammer Payback", "Scammer Revolts", "Trilogy Media" and "Kitboga" on YouTube. Some remotely take over the scammer's computer and download all of their files, including all the transaction logs with hapless victims. Some of these delete the remote data files, screw around with their VoIP phone systems and cameras, and generally create merry hell.

I cannot, of course, suggest that something which might be illegal is worth doing to these scammers, however delicious it might seem. But my experience with the PayPal scam shows that you can't be too careful. I knew something was up because they emailed a lab address that has never had a PayPal account. My PayPal account is on a totally different email address and has two factor authentication enabled.

So please do something for me. Just remind your family and friends, especially elderly relatives, that there are some very nasty people out there who will try the most appalling financial scams on the unwary. And make it your New Year Resolution to keep reminding them.

Jon Honeyball ■

Jon Honeyball
Jon Honeyball promises he won't do a SYSKEY on your computer if you email him with your username and password.

> "It appears that it is possible for PayPal users to generate estimates within the PayPal site, and issue them to random email addresses."

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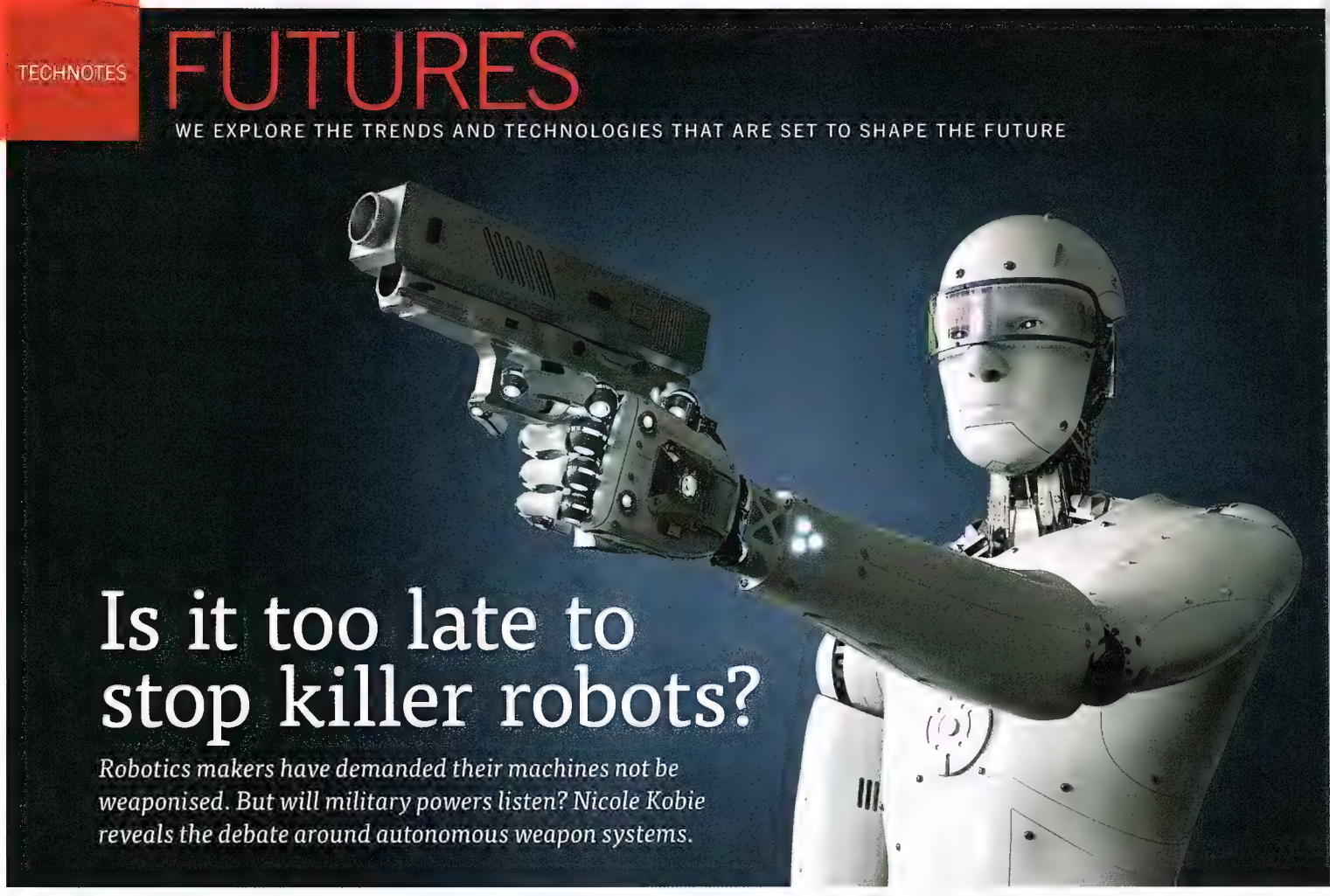


Is it too late to stop killer robots?

Robotics makers have demanded their machines not be weaponised. But will military powers listen? Nicole Kobie reveals the debate around autonomous weapon systems.

Robotics developer Boston Dynamics has a reputation for making robots that jump, crawl and run, sharing online videos of its creations that veer between impressive in their capabilities and hilarious in their limitations – but always terrifying in their potential.

Though it's amusing to watch the company's Atlas humanoid robot dance a jig or stumble attempting parkour, strap a gun to it and the laughs cease. And Boston Dynamics doesn't want to see that happen.

The Massachusetts-based firm is one of six industry leaders, alongside Agility Robotics, ANYbotics, Clearpath Robotics, Open Robotics and Unitree, that jointly published an open letter pledging not to weaponise their general-purpose robots and asking customers to do the same.

"We believe that adding weapons to robots that are remotely or autonomously operated, widely available to the public, and capable of navigating to previously inaccessible locations where people live and work, raises new risks of harm and serious ethical issues," the letter stated. "Weaponised applications of these newly capable robots will also harm public trust in the technology in ways that damage the tremendous benefits they will bring to society. For these reasons, we do not support the weaponisation of our advanced-mobility general-purpose robots."

The firms believe their robots should be used to benefit society, in particular working alongside people in industrial settings or helping in homes. Can a mere request prevent military misuse? The letter suggests the robot makers themselves think not, as the companies not only called on the rest of the industry to make similar pledges and for governments to ban robotic misuse, but promised to take preventative action themselves.

"When possible, we will carefully review our customers' intended applications to avoid potential weaponisation," the letter said. "We also pledge to explore the development of technological features that could mitigate or reduce these risks." Hopefully Boston Dynamics' engineers spend as much time building in those protections as they do creating robots that dance, leap and run.

Killer timing

This sudden fear of weaponisation might come as a surprise to industry watchers who have followed the development trajectory of these companies. Some of the signatories to the letter have long fought weaponisation of robots, notably Clearpath, which in 2014 became the first in the industry to ban weapons from its robots, though it continued working with military partners. But Boston Dynamics has military origins after coming up via DARPA – the US military's Defense Advanced Research Projects Agency, famous as the R&D organisation that's credited (at least partially) with the creation of everything from the internet to GPS.

Stretch is one of only two commercial robots still made by Boston Dynamics.

Killer robots have sparked sci-fi nightmares for decades, and the capabilities of Boston Dynamics' machines have long contributed to those fears. First there was LS3, a four-legged robot created to carry gear for soldiers, like a mechanised donkey of doom. That was followed by Wildcat, another animal-inspired robot that could gallop over varied terrain at a terrifying 32km/h. Then came Sandflea, a small rolling robot with four wheels that could throw itself ten metres into the air, leaping into open windows – think about that when you crawl into bed tonight.

Each of these robots was funded in part by DARPA. But now, all have been retired by Boston Dynamics in favour of just two commercial robots – Spot, a four-legged inspection dog, and

Stretch, a mobile arm designed to unload lorries – as well as the humanoid, bipedal Atlas, which remains a research project.

So why does Boston Dynamics and the rest now want to shrug off their military origins? Perhaps because it's no longer a philosophical quandary but a practical one. It increasingly seems likely that robots will become killers – and may already have done so. James Dawes, professor at Macalester College, Minnesota, says it's thought that 2020 saw a terrible milestone for autonomous weapons systems (AWS), which are machines that can hunt or kill without a human supervisor "in the loop," he explains: they killed a human for the first time.

Loitering munitions

That's according to a UN report about a battle in Libya in March 2020, which saw the use of autonomous drones known as loitering munitions that can choose their own targets, made by Turkish defence firm STM. It's unclear if anyone died in the attacks, but if so it would be a horrific world first, and has been undoubtedly replicated since.

That may sound similar to how drones are already used in warfare; after all, the US has long been using such weapons to kill at a distance. But loitering munitions are seen as a step towards autonomous warfare, as these kamikaze drones, as they're known, hover in the air until they spot their target, be it an anti-aircraft gun, communications antenna or a column of soldiers. Russia has controversially used Iranian-made drones against Ukrainian cities, leading the US to respond by supplying its Switchblade "tactical unmanned system" to Ukraine. The Switchblade reportedly uses GPS for navigation and image processing system to intelligently spot targets.

Like the killer drones that the US has long dropped on Afghanistan, these aren't entirely autonomous – a human has chosen a target, after all. But the drone decides if that is indeed the target before slamming its explosive payload – and itself – into the victim, be it a communications antenna, anti-missile gun or column of soldiers. Even if loitering munitions aren't perfectly autonomous, they're a clear step down the road to killer robots. And everyone from Israel to the US are building and using them.

Top: The LS3 was designed to carry kit for military personnel.
Above: Boston Dynamics' Sandflea can throw itself ten metres into the air.

That's why regulation and international agreement is needed now. "The worry over weaponised artificial intelligence is all about the bright red line of autonomous weapon systems: that's the moment when we turn over the decision over who lives or dies to an algorithm," Dawes explained. "Either we establish an international ban on AWS in the next year or, quite possibly, the technology will have advanced too far, Pandora's box will open, and it will be too late."

Killer robot rivals

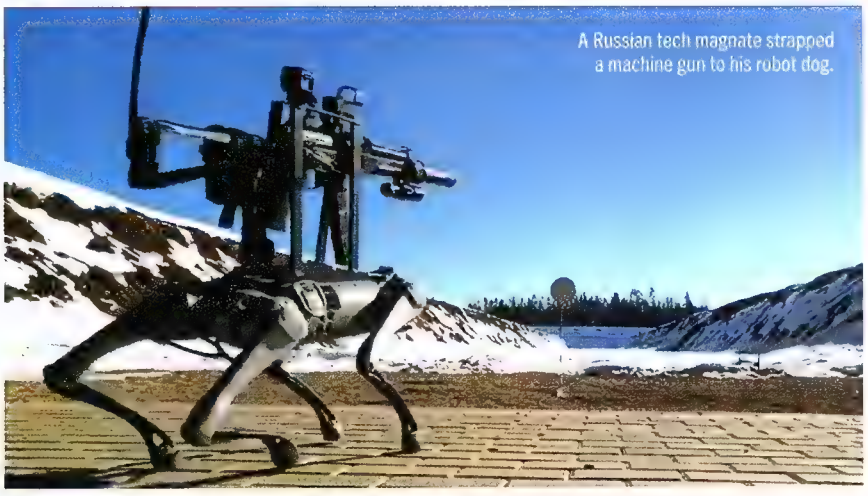
The sextet of signatories that signed the letter are leaders in the industry, but there are plenty of other companies that cheerfully sell weaponised robotics.

American robotics maker Ghost Robotics in 2021 showed off photos of its four-legged Vision 60 sporting a massive rifle, though it doesn't appear to be commercially available yet. In October 2022, the Netherlands rolled out four tank-like robots for testing in Latvia called Tracked Hybrid Modular Infantry Systems (THeMIS) made by Estonia's Milrem Robotics; although it does have weapons, it's remote-controlled rather than fully autonomous. But Israel's version of a killer tank, Israel Aerospace Industries' REX MKII, does have the potential for some autonomous features, though the machine-gun-toting robot is currently controlled by a tablet.

Indeed, the campaign group Stop Killer Robots notes that Boston Dynamics is now owned by Hyundai, which also owns industrial manufacturer Rotem. That company makes walking robots that feature unmanned weapon systems, including one based on Boston Dynamics' own Spot robot.

The open letter points to an additional reason for concern: DIY killer robots. Even if Boston Dynamics doesn't weaponise its own machines, someone else might buy a Spot or a cheap knock-off of it for nefarious purposes. "For those of us who have spoken on this issue in the past, and those engaging for the first time, we now feel renewed urgency in light of the increasing public concern in recent months caused by a small number of people who have visibly publicised their makeshift efforts to weaponise commercially available robots," the letter reads.

In 2021, an artist group called MSCHF Product Studio attached a paintball gun to a Spot, letting people remotely control the dog robot to splatter a gallery. In 2022, a video posted to YouTube showed a Russian tech magnate strapping



A Russian tech magnate strapped a machine gun to his robot dog.

a machine gun to his robot dog, which isn't made by Boston Dynamics but looks similar to its Spot model. While the robot in the video appears to be doing little other than carrying the gun, the fact that innovations made by Boston Dynamics et al will be quickly reproduced by other manufacturers means their work can easily be adapted to military use, whether they want it or not.

There are limits to the pledge itself. The six companies have banned weaponisation of their robots, but haven't ruled out their use for military or policing purposes, such as assisting soldiers carrying loads or surveillance and monitoring. A robot can still hurt humans by carrying a weapon or finding a target, after all – but at least in such cases a human is still "in the loop" with the decision to kill.

"It may also not be that clear-cut in terms of how it plays out: notably, the open letter speaks of 'general purpose' robots that shouldn't be weaponised," added Dr Ingvild Bode, associate professor of international relations at the Centre for War Studies at the University of Southern Denmark. "So, the companies involved may still develop robots for the specific purpose of military use that would supposedly not be covered by this pledge. Many tech companies, including Big Tech, already hold defence contracts, although they differ in how openly they advertise the fact."

Indeed, as she notes, Google employees pushed the tech giant to drop its "Maven" military contract in 2017. "As international polls continue to show significant public disapproval of weaponised AI, tech companies may consider positioning themselves as opposed to this development as an important moral/ethical move," she said. "There is a direct reference to public trust in AI technologies featured in the letter, after all."

In short, the pledge itself is good public relations – and public opinion may force companies to keep to their own promises.

What can be done?

The request by the companies for militaries not to misuse their products at least demonstrates a firm commitment by the robot makers, says Bode, noting that it's a long-running ethical stance for Clearpath in particular. "At the same time, of course, the companies have extremely limited control about what the end users of their products, which may include the military, do with them," she said.

"To govern this space, we would need legal regulation to limit the design and deployment of weaponised AI," she added. "This form of regulation could either come from the national or, ideally, the international level, setting at least the beginning of a uniform standard that militaries have to adhere to."

But finding international agreement isn't easy. The United Nations met in 2021 to discuss the issue of killer robots as part of its convention on regulating weapons technologies. The agreement was blocked by the US and Russia – unsurprising as they've done the same with proposed regulations on other controversial weapons, says Dawes. "So, just as with landmines and cluster munitions, other governments and non-governmental organisations are seeking to establish an international treaty outside the confines of the [UN], where the US and Russia effectively have veto power," he said, adding that's why the open letter has come along at this time: "The private sector is responding to this global pressure."

Diplomacy and international agreements could help stem the flow of such weapons and control their use. But in the meantime, could engineering such as software controls help companies such as Boston Dynamics prevent their innovations from being used to kill? "Efforts have been made to develop programming models of 'ethical governors' that could, for instance, make autonomous weapons obey the international laws of war," said Dawes. "Surely research in this area should continue."

He added: "But here's the problem: just like, in the United States, people have found ways to turn supposedly 'safer' semiautomatic weapons into fully automatic weapons. People – governments, terrorist groups, even individuals – will find ways to circumvent AWS safeguards."

Despite the best efforts of Boston Dynamics et al, then, the slow creep towards killer robots continues. We should take this time to consider the ethical and moral questions of delegating death to AI, says Bode. "Over time, militaries have not only delegated motor and sensory tasks to robotic weapon systems, but also cognitive tasks," she said. "When such delegation of cognitive tasks concerns the targeting of humans, we should be very careful and critical minded because of the effects this 'delegation' has on de-humanising warfare."

In short, war is hell, and AI-operated robots could make it even worse. ■

KILLER AI, NOT JUST ROBOTS

The addition of intelligence into weaponry is a long-running trend that will see artificial intelligence baked into a wide range of weapons. So says Dr Ingvild Bode, associate professor of international relations at the Centre for War Studies at the University of Southern Denmark. "There is [a long] historical trajectory of integrating automation and autonomy into the targeting functions of weapon systems that started with guided missiles and air defence systems in the 1950s and 1960s," she explained.

Such systems have naturally become more sophisticated, making regulation all the more necessary. "We now have systems integrating autonomous and AI-enabled functions in targeting in weapon systems in air, on land and at sea," Bode said. "This is a development in dire need of legal regulation... Open letters of the kind under-signed by Boston Dynamics are certainly to be welcomed, but much more is needed to properly govern this space.

"AI can be weaponised across many different kinds of weapon platforms," warned Bode. So don't just be afraid of killer robots.

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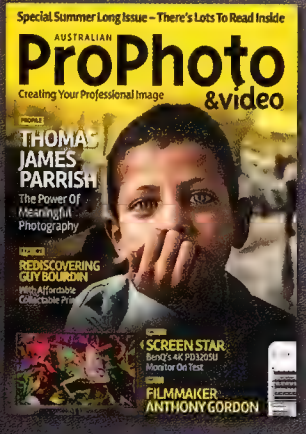

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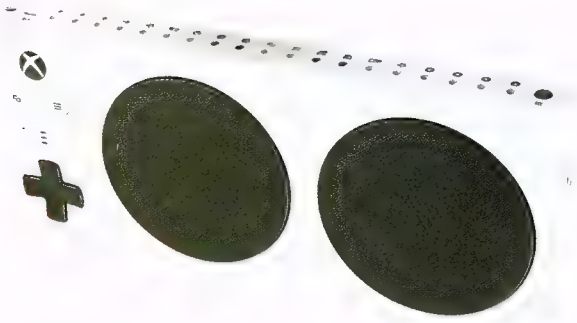
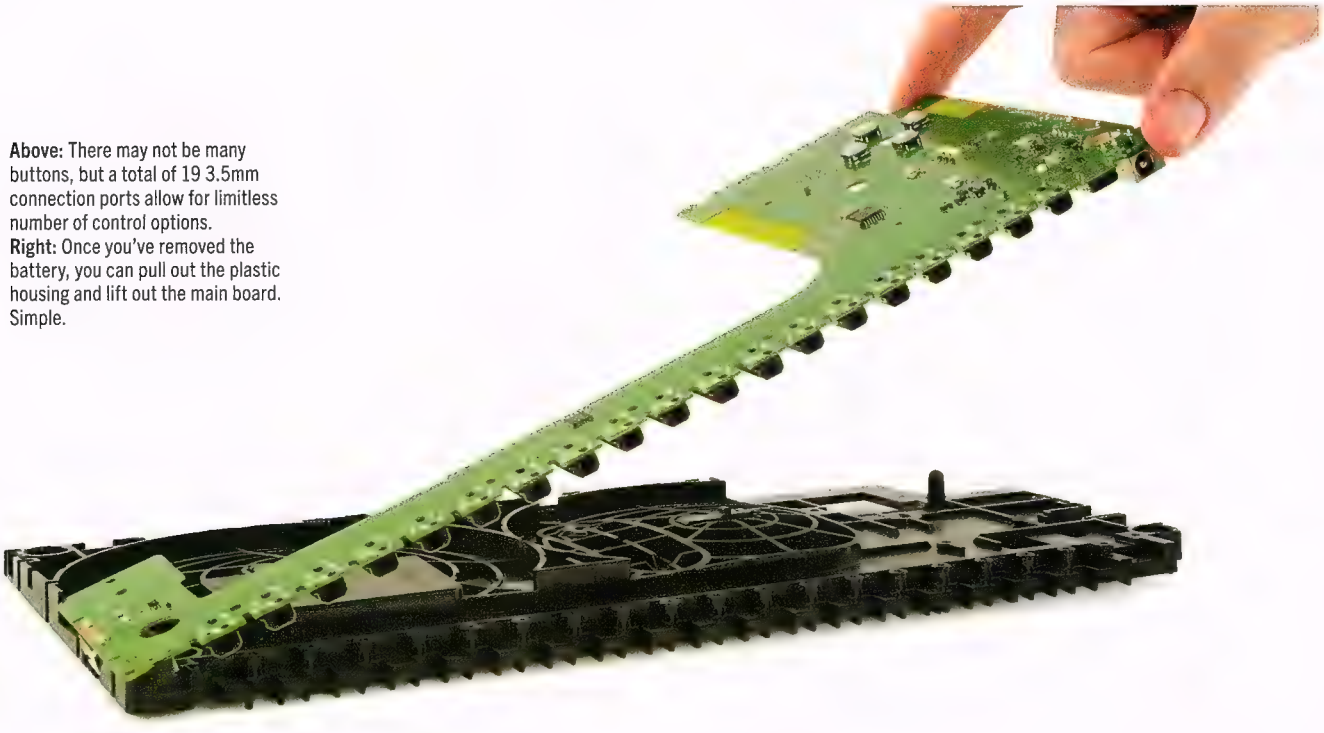
FUTURE

HOW IT WORKS

Xbox Adaptive Controller

The Xbox Adaptive Controller has been built from the ground up to allow accessible gaming. It features programmable buttons and lots of ports for external switches, buttons, mounts, and joysticks.

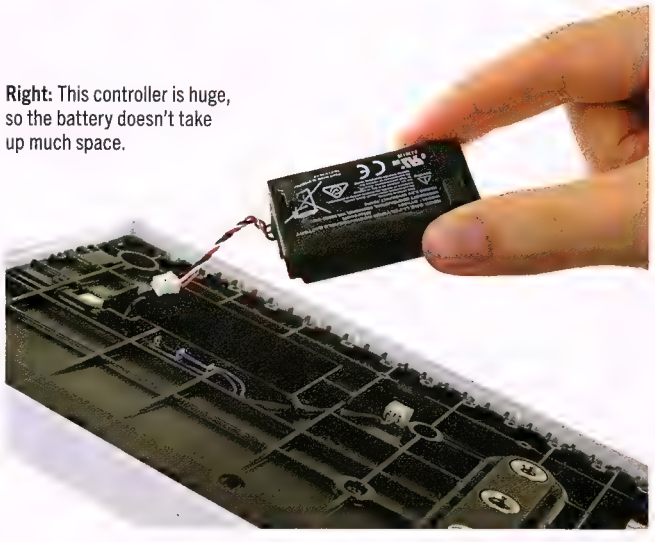




Above: There may not be many buttons, but a total of 19 3.5mm connection ports allow for limitless number of control options.
Right: Once you've removed the battery, you can pull out the plastic housing and lift out the main board. Simple.

Above: The packaging has been designed to be as accessible as possible, with lovely big handles for lifting out the hardware.

Right: Four rubber feet conceal the T9 Torx screws needed to open the controller up and find out what's inside.



Right: This controller is huge, so the battery doesn't take up much space.

Major tech specs

- Compatibility: Xbox One, Xbox Series S/X, Windows PC
- Dimensions (HWL): 23 x 130 x 292mm
- Wireless Protocols: Xbox Wireless Adapter, Bluetooth
- Mount Compatibility: 1/4-20 screw for AMPS, °-20 tripod screw
- Charging: 9ft USB-C cable, 7.79 Wh rechargeable Li-Po battery
- Ports: 19x 3.5mm, 2x USB 2.0, USB-C, 3.5mm stereo jack
- Weight: 552g
- Price: $129

Key findings

- Microsoft's Xbox Adaptive Controller is the most customisable game controller ever made, and is designed to be as adaptable as possible, at least on the outside. The main unit is flat and can be mounted onto a tripod for those who may struggle to grip a traditional controller. The rear panel has an astonishing 19 3.5mm connection ports, representing each of the buttons, sticks, and triggers used in the Xbox control scheme. These can be connected to switches that can be controlled by your head, foot, or mouth, many of which are made by medical supply companies and can cost up to $300 apiece. It's a remarkable bit of kit for gamers who cannot use a traditional controller.
- Special praise must go to Microsoft's packaging team. The boxes all have ring-pull-style fasteners that don't require scissors and, in the box, big handles pull out the device, making it as easy as possible to get to the product. The unit is wider and flatter than the original Xbox controller, with two large buttons on top mapped as 'A' and 'B' by default. The side boasts a 3.5mm headphone socket, while the rear has a USB-C socket for the long 9ft cable – another thoughtful design. There's an internal battery, so no worrying about finding AA batteries.
- We want to find out whether the Xbox Adaptive Controller is as customisable on the inside. Flipping it over, we find four rubber feet that need to be peeled back to reveal T9 Torx Security screws. Not our favorites, but still an easy way to access the internals. Inside the back panel is a Microsoft easter egg – an engraving of a honey badger. Don't ask us what the relevance is, but it's a bonus for those unafraid to open up their products.
- The first thing to come out is the 7.79Wh Li-Po battery, which is about the same size as the two AA batteries in the standard Xbox controller. The battery needs to be removed so that the plastic covering the main board can come out. There's some encouraging news, in that the headphone port is modular and can easily be replaced. The other 20+ ports, however, are not.
- The plastic and the mainboard are tied together with 12 Torx security screws and one Phillips screw, which seems overkill. There's only one board, but so many ports are soldered down, so it will be difficult to service if any break. On the plus side, it's unlikely you'll use all 19 ports, and everything can be modified in software, so you can use another port and remap its function in the app. The buttons on the controller use plastic covers and spring mechanisms, so they won't be easy to replace.
- Repairability score: 7 out of 10 (10 is easiest to repair). We wish Microsoft had used more standard screws on this controller, but at least there's no adhesive in sight, which means disassembly is straightforward and non-destructive. The battery is the most likely component to need replacing, which can be done by removing four screws. However, high wear-and-tear components, such as the springy A and B button covers, will require special tools to repair if they break. ■

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RAZER BLADE 15 (2022)

A SUPERBLY ENGINEERED GAMING POWERHOUSE

Right now there's just not another better gaming unit around. It's miraculously thin considering the beefy components inside, thermals are very well managed and the Razer Blade 15 manages to extract very good performance from its GPU without undue throttling. There are many variants and options, and they're an outstanding buy if you find one on sale. **~$4,499, razer.com/au-en**

ALTERNATIVES

LENOVO LEGION 5I PRO (16IN)

A great-value gaming laptop that's extracts the most from its powerful components. We really love the keyboard, too.

From $2,649, lenovo.com/au

NEW ENTRY

AORUS 17

If you're after a device to seriously game on, and you don't care about the bells and whistles then this is a great option that cuts costs in all the right places.

$3,699, gigabyte.com

ASUS ROG ZEPHYRUS G14 (2022)

A powerful gaming ultraportable that lights up for both work and play. The AMD CPU and GPU balance well.

$3,99, asus.com/au

BUSINESS LAPTOPS

DELL XPS 13 PLUS

DELL'S NEW FLAGSHIP IS A STUNNER.

The updated XPS's headline features include a notably more powerful Intel 12th generation CPU, an optional OLED touchscreen panel, an integrated glass touchpad palmrest and a neat capacitive touch bar. A powerful luxury laptop that's up there with the very best.

$2,339, dell.com/en-au

ALTERNATIVES

LENOVO THINKPAD Z13 GEN 1

The perfect laptop for executives, with amazing battery life backed up by strong performance. A great debut for the Ryzen Pro 6850U.

$2,929, lenovo.com/au

LENOVO THINKPAD X1 CARBON GEN 9

A business laptop with heaps of luxury, especially if you choose the top-end model with a 3,840 x 2,400 screen.

$2,959, lenovo.com/au

DYNABOOK PORTEGE X30W-J

This 2-in-1 convertible is ludicrously light and slim, and offers a quiet keyboard, great performance, ports a-plenty, and a nice touchscreen.

$2,083, anz.dynabook.com

EVERYDAY LAPTOPS

MICROSOFT SURFACE LAPTOP GO 2

FEELS LIKE A PREMIUM ULTRABOOK, BUT COSTS HALF AS MUCH.

A solid update to an amazingly good value mid range ultrabook. It runs cool and quiet, and has up to 30 percent better battery performance than its predeccessor, all in a beautifully designed form with a superb keyboard and trackpad.

From $1,099, microsoft.com/en-au

ALTERNATIVES

LENOVO YOGA SLIM 7 PRO

A powerful, well designed ultrabook with an awesome OLED screen for a good price. The original 2-in-1 bends into a new clamshell shape.

$1,699, lenovo.com

HP ENVY 13 (2020)

It may not be the world's most exciting laptop, but the Envy 13 is a compact and forward-looking machine that's ideally suited to these homeworking times.

$1,699, store.hp.com

HP PAVILION 14

This slim 1.4kg laptop is a superb choice for anyone on a tighter budget. it struck an excellent balance between speed and battery life – around ten hours.

From $999, store.hp.com

CHROMEBOOKS

ASUS CHROMEBOOK FLIP CX5

The best big-screen Chromebook we've tried, with a bright 15.6in Full HD display with decent black levels and surprisingly rich colours. And it's a good specification for the price, with a Core i3 processor, 8GB of RAM and a 128GB SSD in tow.

$1,213, asus.com/au

LENOVO FLEX 3 CHROMEBOOK

This isn't the most powerful Chromebook, but students need reliability more than power – especially if they're only really using it for homework, note-taking, and perhaps the occasional bit of Netflix.

$484, lenovo.com/au

LENOVO IDEAPAD DUET

The Chromebook answer to Microsoft's Surface tablets, this is a seriously versatile device – albeit not the speediest (although we never found it to be painfully slow while carrying out everyday tasks). For this price, and with a 16hrs 14mins battery life, the Duet is a great choice.

$899, lenovo.com/au

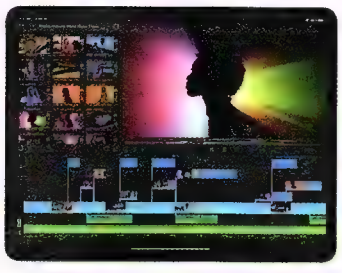
TABLETS

APPLE IPAD PRO 12.9IN (2021)

M1 POWER IN YOUR PALM FROM $1,199

Blurring the boundaries between laptop and tablet like never before, the M1-powered iPad Pro 12.9-inch is every bit as fast as we expected – and the "Liquid Retina XDR" display is simply phenomenal.

From $1,649, apple.com/au



APPLE IPAD (2021)

Apple performs its usual trick of upgrading just enough to keep the iPad affordable and up to date, without treading on the toes of its more luxurious stablemates. The big bezels remain, but a faster processor, more storage and improved camera all add to its appeal.

From $499, apple.com/au

SAMSUNG GALAXY S8 ULTRA

The Samsung Galaxy Tab S8 Ultra is an enormously impressive tablet. It makes a fantastic first impression with its gorgeous screen and thin body, and is great for multitasking. If you want the best Android tablet going, there's no question at all that this is it.

$1,499, samsung.com

EVERYDAY MONITORS

PHILIPS BRILLIANCE 346P1C

34-INCH CURVED DOCKING,

No-one can match Philips for its mix of quality, features and value, especially when it comes to curved MVA monitors such as this. It's great for casual gamers and busy workers alike, with USB-C docking and superb colours.

$849, philips.com.au

EIZO FLEXSCAN EV2480

Businesses in particular will love this easy-to-roll-out 24-inch monitor, with its exceptional five-year warranty, USB-C port for easy docking, excellent viewing angles and delicious whites. And it has the best OSD around.

$699, eizoglobal.com

DAHUA DHI-LM28-F420

This affordable 4K monitor might not offer much in the way of menu options or high-end gaming perks, but it offers impressive resolution and colour for ally pay.

$269, dahuaaustralia.com.au

PROFESSIONAL MONITORS

EIZO COLOREDGE CG319X

CREATIVE MASTERCLASS, $7,119

As the price indicates, this monitor is for heavyweight creatives who demand the best in every discipline: HDR video editing, print layouts, professional photography and more besides. With superb coverage and accuracy across all spaces, plus a built-in calibrator, it justifies the investment.

$7,119, eizoglobal.com

BENQ PD2725U

By no means a cheap 4K 27-inch monitor – unless you compare it to the Eizos – but it marries all-round quality with ease of use thanks to a puck that allows you to quickly move between settings. You can even daisy chain a second Thunderbolt 3 monitor for a monster setup.

$1,799, benq.com

EIZO COLOREDGE CG279X

Designers who need to work across different disciplines will love how easy it is to switch between the Adobe RGB, DCI-P3 and sRGB colour spaces using the Eizo's fantastic OSD. It's certainly not cheap for a 27-inch 1440p monitor, but it's packed with quality.

$3,095, eizoglobal.com

HOME OFFICE PRINTERS

EPSON ECOTANK ET-1810

BACK TO BASICS

There's nothing flashy about this bottle- fed inkjet: it's there to churn out pages at a decent rate (8.8ppm for black text) for a low price. It comes with enough ink for 4,500 black pages and 7,500 in colour, but refills are cheap. Just don't expect features like duplex printing.

$299, epson.com.au

CANON PIXMA PRO-200

Yes, it's big and it's expensive – and you don't even get a scanner – but the Pixma Pro-200 means that you can print A3 photos with glorious colour accuracy and detail. If you're after an office workhorse, look elsewhere, but it can't be beaten on photo quality.

$809, canon.com

BROTHER MFC-J4540DWXL

Home workers will love this inkjet all-in-one. It combines an incredible range of features with all the connectivity you need and extreme ease of use. Output quality is fine, it offers the best cloud support around and the high-capacity ink pack could keep you going for years.

$420, brother.com

WIRELESS ROUTERS

SYNOLOGY WRX560
THE PERFECT ROUTER
Its quad-band Wi-Fi smashed-through our performance tests managing 791.5Mbps up close, 375Mbps two rooms away and an amazing 216.7Mbps down the garden..
$599, synology.com/au

ASUS RT-AX82U
The impressive RT-AX82U punches well above its price when it comes to raw Wi-Fi 6 performance and includes a fistful of useful features – such as an ultrafast 20Gbits/sec USB connector, outbound VPN support, site-blocking and a host of parental controls.
$320, asus.com/au

SYNOLOGY RT6600AX
Fast, well-featured and secure, the Synology RT6600ax is as perfect for professionals and prosumers as much as it is for SMBs and smart homes, and the app and interface are a delight to use for both experts and plug and play users alike.
$599, synology.com/au

MESH WI-FI

TP-LINK DECO XE75 AXE5400
SUPERB WI-FI 6 MESH
Offers the simplicity, speed and range most people want from a mesh system. While it's expensive, nothing else offers the plug-and-play simplicity, speed and range afforded by the Deco XE75.
$999, tp-ink.com

TP-LINK DECO X20
The price below isn't a typo: the Deco X20 makes it possible to upgrade your home network to Wi-Fi 6 – as well as manage its security – for the price of some standalone routers. The included HomeCare functions are also a great bonus for households where lots of devices are fighting over the bandwidth. **$199, tp-link.com**

ASUS ZENWIFI AX
The interface and design certainly aren't the prettiest (the nodes look like mini space heaters, while the charcoal version is straight out of the 1980s), but if you're after strong performance, great features and plenty of expansion potential, the ZenWiFi AX is a compelling prospect.
$949, asus.com/au

NAS SERVERS

QNAP TS-130
SIMPLE HOME NAS
An above average CPU and RAM combo, solid features and affordable price make the QNAP TS-130 worth considering. Alternatively there's the two bay TS230 which features the same CPU, with 2GB of RAM, dual drive bays, and an extra USB port on the front for a modest $50 price increase.
$250, qnap.com

ASUSTOR NIMBUSTOR AS5304T
This is a hugely powerful four-bay NAS that will be overkill for most people – not just due to its speed but also its slightly intimidating user interface – but techies and gamers should investigate the Nimbustor AS5304T for both its speed and flexibility.
$799, asustor.com

SYNOLOGY DISKSTATION DS1522+
At $1,199 it's not cheap but factoring in the software means it's great value. Though some internal silicon may lack headroom, this is still a well-featured, expandable NAS with fantastic software. The best part is the DSM software.
$1,199, synology.com

SECURITY SOFTWARE

F-SECURE SAFE
F-Secure concentrates on the basics: faultless protection with minimal impact on your system's performance – for a low price.
1-3 PCs, 1yr, $99.99, f-secure.com

ALTERNATIVES

NORTON 360
Consistently on the podium in our group tests, and loaded with an abundance of genuinely useful features, including a VPN and generous cloud backup.
1 PC, 1yr, $79.99, nortonlifelockpartner.com

AVAST FREE ANTIVIRUS
For the second year running, Avast is our top pick for free antivirus software – it's simply lighter on its feet than Microsoft Windows Security, whilst offering fewer false positives.
Free, avast.com

VPNs

NORDVPN
NordVPN provides consistent and fast speeds, serious security, great support for video-streaming services and some cost-effective subscription rates.
$59 per year, nordvpn.com

ALTERNATIVES

PROTONVPN
ProtonVPN provided one of the best free offerings of all the VPNs in our group test, including unlimited data, but upgrade to benefit from even faster speeds and many more options.
Free, protonvpn.com

SURFSHARK
A strong rival to NordVPN, especially if you're willing to commit to its two-year contract. It's fast, cheap and a fine choice for people who like to switch to US streaming services.
$66.34 for one year, surfshark.com

PASSWORD MANAGERS

BITWARDEN
Bitwarden has a huge advantage: it's free. It isn't as slick as some paid-for rivals, but it can sync passwords across all devices for no extra charge. **Free, bitwarden.com**

ALTERNATIVES

DASHLANE
A manager that's ideal for beginners, and it even builds in an unlimited (if basic) VPN service. Note you may prefer to buy the Family plan ($60 per year) as this extends the service to six people.
$55.99 per year (Premium), dashlane.com

1PASSWORD
1Password is targeted at technically minded users who are looking for the last word in security. It even offers a Travel Mode that may ease your mind if surrendering your phone to customs officials.
$54.99 per year (individual), 1password.com

72
techradar.
The source for tech buying advice
techradar.com

HEAD TO HEAD

Authy vs. Google Authenticator

Which is the better two-factor authentication app?

■ AUTHY | $free | www.authy.com
■ GOOGLE AUTHENTICATOR | $free | www.googleauthenticator.net

Logging in to a service can be a real pain these days, in between being asked to change your password every six months, having to remember which street you grew up on as a child, or requiring you to check your phone for a text message code before you can gain access. So a request to set up two-factor authentication (also known as 2FA) might seem like yet another annoying layer between you and whatever account you're trying to access.

But it is really important to enable 2FA on any services that offer it, because it means that, even if your password is compromised, any malicious users won't be able to log in to your account without that code, which only you should have access to. This is especially important on any services where your financial information could be accessed or compromised, as 2FA acts as a barrier between your money and a nefarious user.

Hopefully, within the not-too-distant future, we'll be able to do away with passwords and 2FA altogether with biometric-based security. Microsoft has already enabled this for its own services via its Authenticator app. But for now, 2FA is an important security option for those services that offer it.

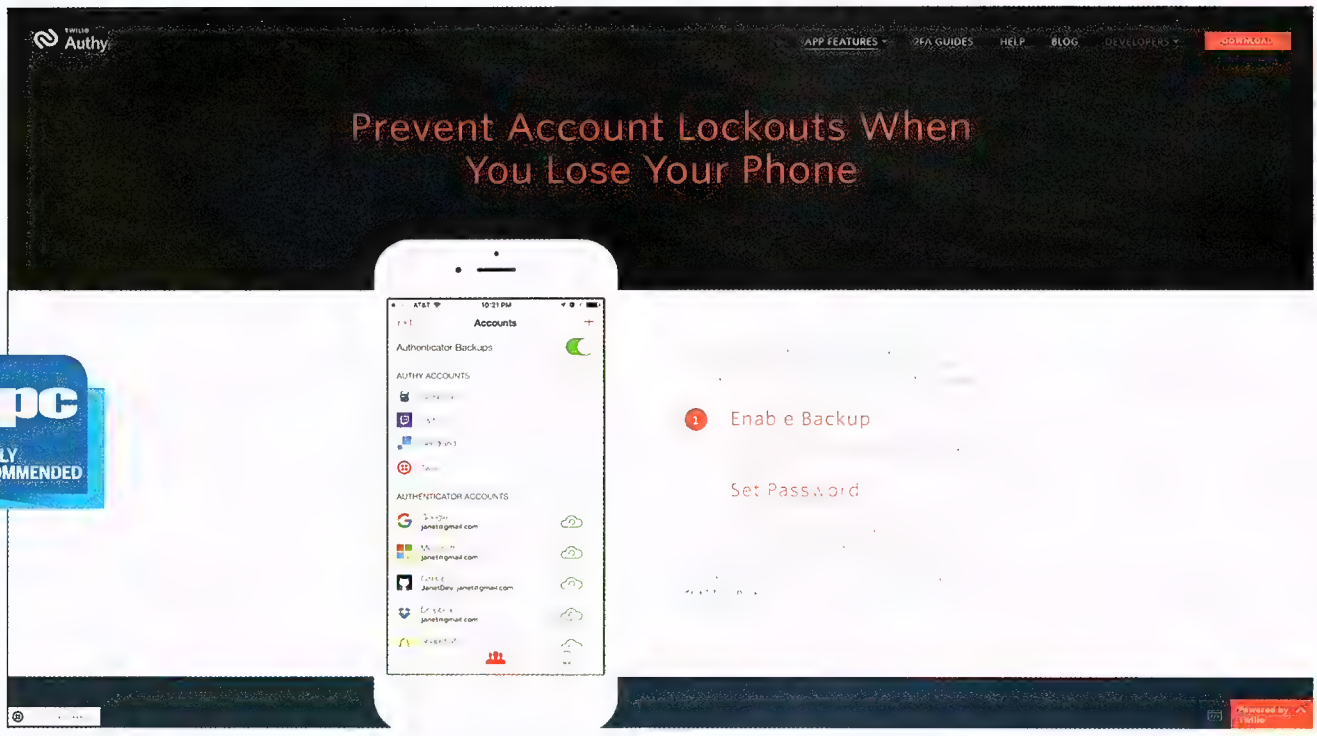
There's a de facto standard when it comes to 2FA, and that is Google Authenticator. Indeed, many services will explicitly tell you to use Google's app to scan the QR code that's displayed during the setup process, probably because it's assumed that over 50 percent of people will be using an Android smartphone, and if not, they will still have a Google account for which they can remember the password. But there are lots of different authentication apps, including Microsoft's aforementioned effort, LastPass Authenticator, and Zoho OneAuth, all of which do the job of providing you with a unique code when a 2FA-enabled website, app, or service requests one.

All authentication apps work in the same way – when you enable it on your chosen service (Facebook, for example), the site will create a QR code that you scan using your chosen app. The app will then display a six-digit code that you input into the service to confirm, and that's it. From then on, the app creates a new code every 30 seconds, and when the service requests it, you simply open up your app and input the code.

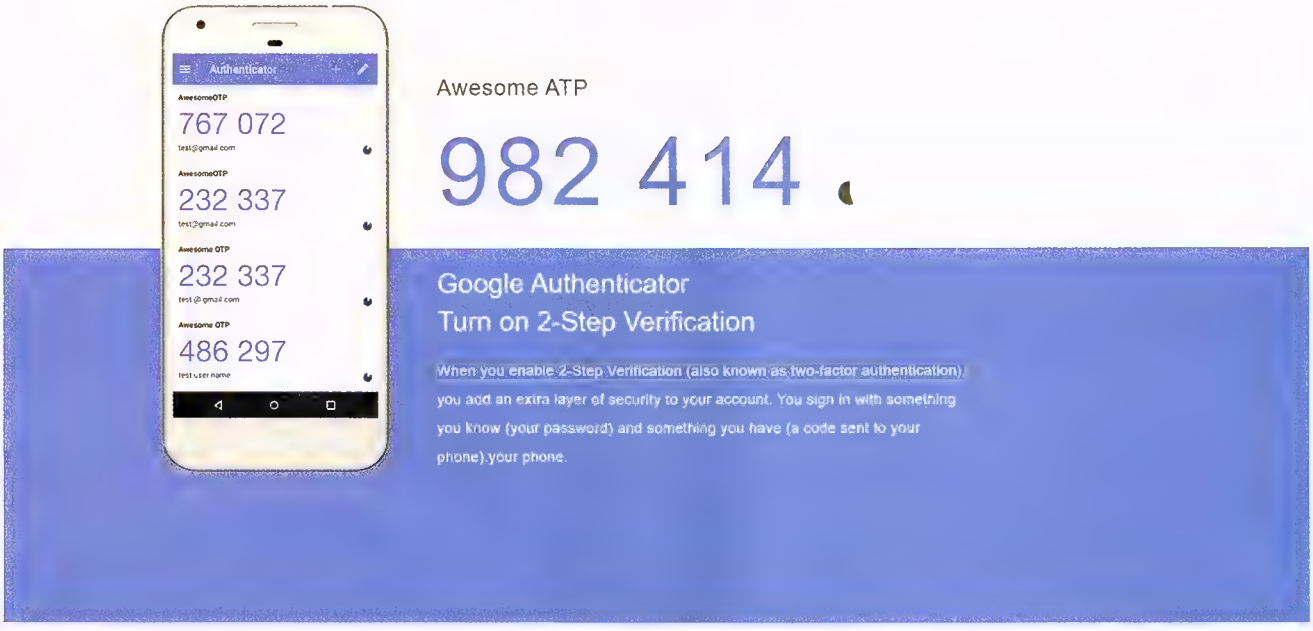
One service might ask you for a code every time, whereas others might only do it when it suspects something has changed – you might not have logged in for 30 days, for example, or you have tried logging in from an IP address that the service doesn't recognise. In this head-to-head, we'll be looking at the two most used and feature-rich options currently out there, Google Authenticator and Twilio's Authy.

Google Authenticator was the app that started it all and set the standard for two-factor authentication, and as such is a solid and dependable choice. The app is available on both Android and iOS platforms, meaning you'll need a phone or tablet nearby whenever you're asked for a 2FA code. Your codes can be moved over to a new device by exporting via a QR code, meaning if you ever move devices in the future, you can still access all of the services you need.

That's the theory, anyway – in practice, Google has sometimes been



Authy is a great 2FA app but its killer feature is the ability to sync across devices, which means you can access your codes wherever you are.



Google's app is the default 2FA app for many and it works fine. But it's nowhere near as easy to use or as flexible as Authy.

slow to update its app for new mobile operating systems, which has meant users have been unable to open the Authenticator app at all. That's unforgivable in this always-connected world, especially as Google offers no way to get your 2FA codes online or through a browser.

Google's interface could also do with a makeover, because as you build up a library of services using 2FA, it can be time-consuming to scroll through the list in the app. This is compounded by the fact that Google's app doesn't create icons for you, which would make it easier to distinguish between Twitch and Facebook at a glance, for example.

The colour of money

Authy by Twilio does the same basic job as Google Authenticator, but it has developed over recent years to offer a lot more functionality compared to its big-name competitor. It still lists all of the services you add to it, but it will usually try and automatically add a logo when you scan the QR code, making it much easier to find a service when scrolling through the list on your phone. And if there isn't a logo available, you can use different colours of the default key logo to colour code your services.

That's not all when it comes to features with Authy, as it goes way above and beyond what's offered by Google Authenticator. Your accounts can be backed up online, meaning that if you lose your device, you can still log into Authy and access all of your 2FA codes. This also applies to running Authy on multiple devices at once – I run it on both my Android phone and Android tablet, which is handy for when I sometimes leave my phone in a different room. Authy also has a smart feature where you can simply hit 'approve' from a pre-existing version of the app when you're setting it up on a new device – you don't have to enter your password each time.

Authy feels more secure than Google Authenticator, as you can set it up with its own security settings. For example, you can set a PIN in order to open the app, or use your device's biometric security such as fingerprint or FaceID every time you want to access it. Not everything is great about the mobile app, however – there's no easy way to automatically sort all of your services in alphabetical order, so you have to do it manually. You sometimes have to go back and manually edit the names given to your services, as you'll find services that are just named after your email address or username with no other context provided.

Authy's killer feature, though, is that it runs not just on phones, but pretty much every device going, including Windows, Linux and macOS. That means you can access your codes directly from whatever device you're using, as well as copy and paste without having to use another device and type it out manually. While some people will feel less secure if they have Authy running on lots of different devices, you can always log out any other device from the app's settings, as well as see when they were last accessed.

Usually these software head-to-heads are relatively close, but in this instance there really is no contest between these two – Authy is the far better 2FA service. The most important thing to take away from this article is to enable 2FA where available, and if you prefer to use Google Authenticator or any other app to do this, then that's better than nothing. But really, there's no reason not to use Authy as your two-factor security option, because its features and flexibility make it as easy as possible to make every account you use as secure as it can be.

Authy Works across devices, auto online backup in case of device loss, logos make it easy to navigate. No way to sort alphabetically on mobile, basic interface, some services require manual renaming to make sense.
Guy Cocker

★★★★½

Google Authenticator Ubiquitous, simple to set up, easy transfer between devices. No online backup or sync, only works on mobile and tablet, no logos to distinguish between services.
Guy Cocker

★★★½☆

TECHNOTES

Gadgets

Happiness bringers.

❶ CAKE KALK&

You may not be able to eat it, but you can at least have this sci-fi cake.

US$14,860 | ridecake.com

If you're into a sci-fi aesthetic then there's really only a handful of cars that you can get right now... but electric motorbikes are a totally different story. The Kalk& street-legal off-road electric bike from Cake, for example, is an app connected full-future looking electric bike available at Deus stores locally. You can ride this as your daily commuter or take it up the steepest goat tracks you're willing to tackle. The lightweight bike offers 252Nm of instant torque to get you to the 90km/h max speed impressively quickly and you'll get a maximum range of 86km for urban rides.

❷ ASTELL&KERN AK HC3

Get DACked

$299 | busisoft.com.au

It seems the music nerds didn't have their pants removed in public enough as kids, otherwise why else would they still be so keen on getting DACked when out and about? If you want MQA 8X audio from your laptop or phone while you're off jet-setting then the Astell&Kern AK HC3 is the Digital Audio Converter for you. For those that have never heard of Master Quality Authenticated (MQA) then maybe just shove that AirPod back in and tune out, but for those in the know, then a USB-C or Lightning compatible DAC that runs off the connected device's power is a neat addition to your audio kit.

❸ RYIDAR LINKLENS PRO 2

Smarter snow audio to keep you safe on the slopes.

$288 | ryidar.com

Being able to listen to music while you ski or snowboard is an awesome perk for those moments when you don't have a buddy to keep you company, but using your normal ear pods or headphones can make it hard to hear what's going on around you. Non audio-occluding headphones like those built into the LinkLens Pro 2 make it possible to hear music and phone calls without blocking out the important sounds around you. The two open-air audio drivers push surround sound audio to each ear while the wide 170-degree field of view lens allows you to see in every direction.

4
SENSIBO PURE

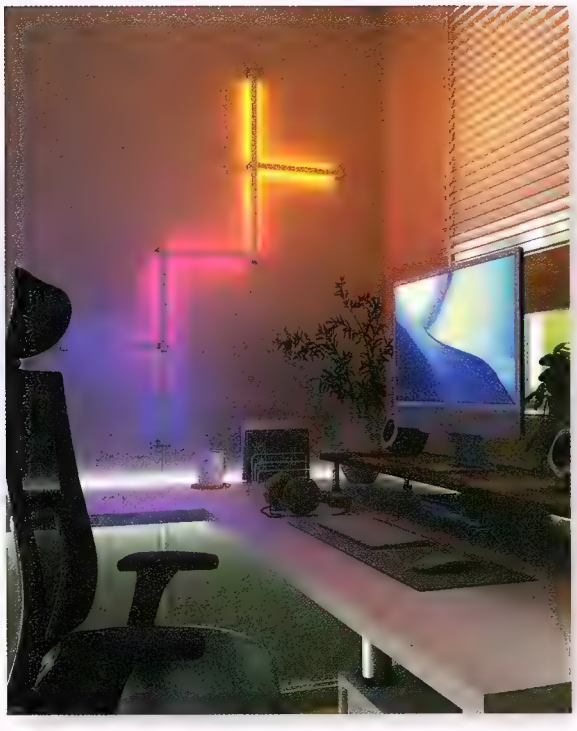
Cleaning the spot you missed in your house.
$259 | sensibo.com

Sensibo, the company that makes universal smart remotes for air conditioners, has launched an air purifier that'll help you be aware of what's in the air you're breathing. Being careful of what you're breathing will probably seem trivial to most, but for anyone living in an urban environment, everything from your car to your new sofa is capable of producing harmful airborne chemicals that can have dramatic short-term and long term impacts on your health. The Sensibo Pure will constantly monitor the air quality in a room and will turn on its filtration system if it detects harmful pollutants.

5
EPSON EH-TW6250 4K PRO UHD HOME THEATRE PROJECTOR

Take your gaming to the big time with this new large format upscaled 4K projector.
$2,099 | epson.com.au

4K home theatre projectors aren't exactly new, but with each new instalment they get slightly closer to the best monitors on a super scale. The EH-TW6250 doesn't have the 120/240Hz refresh rates of the best gaming projectors, nor is it actually true 4K (it's actually just running an upscaled 1080p image), but this new gaming projector does offer sub 20ms latency to keep you from feeling like your trying to run underwater when playing games. Playing games on a 500-inch screen is a pretty awesome experience, even if it's not a format you'd want to play competitively on.



6
NANOLEAF LINES SQUARED

More than just a bit of flash.
$229 | nanoleaf.me

This 'Squared' evolution of last year's Nanoleaf Lines home-discofication lighting system adds a couple of neat touches. In terms of aesthetics, this kit, which comprises four light sticks in the Starter Kit, can be arranged in 90 and 60 angles, so you can do tricky things like surround a door frame or window. They know when a new line is added, or rearranged, too. Fully compatible with all the smart home standards of course – and the other interesting aspect is that the Lines Squared serves as a Thread Border Router, which is part of the new Matter common standard, meaning these sweet things not only emit 16 million shades of colour, but also a Wi-Fi signal to boost your coverage.

2-IN-1

Microsoft Surface Pro 9 (Intel)

The new Intel powered Surface Pros get new processors and some other minor tweaks.

■ $2,549 | microsoft.com/en-au

■ W11 Pro; 13-inch PixelSense 120Hz display at 2880 x 1920 pixel resolution; Intel Core i7-1265U CPU; 16GB RAM; Intel Iris Xe GPU; 256GB PCIe SSD; 46Wh battery (8h 29min 1080p movie playback); 27.8 x 20.9 x 9.3cm; 879g (1.173kg with keyboard).

Microsoft has kept the Surface Pro a leading 2-in-1 device by offering predictable updates, and while the integration of the Surface Pro X range is a big shift this year, for the most part, the Surface Pro 9 is another iterative update. Seven of the eight new Surface Pro 9 models from Microsoft use 12th generation Intel i5 or i7 processors that improve overall performance and offer even better battery life over previous generations. We were not impressed by the SQ3 powered Surface Pro 9 (opposite page), but the rest of the range showcase incremental improvements that push the Surface Pro line forward without fundamentally shifting what you'd expect from them.

The new Intel processors shift to a 10-core 12-thread arrangement from a quad-core eight-thread layout on the Surface Pro 8 which delivers solid performance bumps in certain tasks and helps with overall battery life. You can configure the Surface Pro 9 Intel variations with either the Intel Core i5-1235U that start at $1,649, or the i7-1265U CPU which starts at $2,549. We benchmarked the latter and saw around 30 percent improvements over a comparable Surface Pro 8 in tasks that utilise multiple threads, while more generalised work benchmarks that rely on processor speed remained within a few percent of the previous generation.

There was a major update to the screen on the Surface Pro 8, so the Surface Pro 9 keeps the same 13-inch PixelSense Flow screen as its predecessor. The 2880 by 1920 pixel display still offers a rich and detailed image against competitors and the screen is capable of running up to 120Hz for more fluid movement in videos and games. The screen does add Dolby Vision IQ, which is a new HDR specification that includes adaptive colour based on the ambient lighting in the room. It's not a game changing technology but should help mediate some of the lack of visibility you might occasionally see in low light cinematography.

This update brings the new WiFi 6E networking specification that will make connectivity much faster over congested networks by utilising a range of 6GHz bandwidths to transfer data at higher speeds when closer to a compatible router. It's also got an updated SSD with 3,502/2,527 MB/s respective read and write speeds, roughly 1,000MB/s improvements over the Surface Pro 8. There's also around an hour's extra battery life on the Surface Pro 9 with over 10 hours of intermittent work or 8.5 hours of movie playback.

As with the screen, the Surface Pro 9 benefits from its predecessor's updates to the Signature Keyboard and the Slim Pen 2 which integrates the pen into the keyboard so you have it at all times. These are some of the best accessories you can get for a tablet, but they do add an additional $429.95 to the price which pushes the Surface Pros to an expensive price point that's well over what you'd expect to pay for a clamshell laptop.

One other development is that Microsoft has quietly ditched the 3.5mm headphone jack. Considering how developed the wireless headphone market is these days this isn't a major omission by any means, but it's still something that would have stung less if Microsoft had bundled its $16 USB-C to 3.5mm jack audio adapter or offered a discount on one of its wireless headphone offerings.

A solid processor upgrade to the world's leading detachable tablet laptop.

Joel Burgess

★★★★☆

2-IN-1

Microsoft Surface Pro 9 (SQ3, 5G)

Microsoft has partnered with Qualcomm to make an ARM-based Surface Pro, again.

■ $2,599 | microsoft.com/en-au

Perhaps the biggest update of the Surface Pro 9 range is that Microsoft has rolled in its Surface Pro X range into the standard 'Surface Pro 9' named lineup, suggesting this device might be ready to keep up with Intel's offerings. We hate to be the ones to burst that bubble, but Microsoft's Qualcomm built SQ3 ARM-based processor requires a willingness to massively sacrifice hardware performance and software compatibility in order to have a more smartphone-like experience, so in our opinion it should have definitely been kept as a separately named product.

We're not talking a little performance loss here, the Surface Pro 9 with the Microsoft SQ3 processor is getting performance in the ballpark of a 2019 Surface Pro 7 running 10th generation quad-core Intel processors on many benchmarks. Sure the ARM based processors only have access to some of the benchmark applications we use to test laptops, so there is potential that it runs really well on some specific untested software... but narrow platform capability is hardly a key selling point. In fact that's arguably what was the biggest shortcoming of the Windows S platform.

It's disappointing to see Microsoft still fumbling in this department considering just how well Apple has managed to make RISC hardware perform in 64-bit environments. You can see that Microsoft isn't oblivious to what Apple is doing, regularly referring to the SQ3's AI powered Neural Processing Unit in key branding material, even though it's primarily used to create fancy web conferencing filters rather than Apple's Neural Engine which helps it translate Reduced Instruction Set Computer (RISC) language into what you need to run full pc applications. So while an M1 or M2 chip can run any 64-bit Mac OS software, the Surface Pro 9 running an SQ3 simply can not run any software that hasn't been specifically built to run on Sanpdragon's PC platform, so you're frequently going to run into apps that just aren't compatible.

■ W11 Home on ARM; 13-inch PixelSense 120Hz display at 2880 x 1920 pixel resolution; Microsoft SQ3 processor built by Qualcomm; Microsoft SQ 3 Adreno 8CX Gen 3 Graphics; 16GB RAM; 46Wh battery (14h 18min 1080p movie playback); 28.7x209x9.3mm (without keyboard); 879g (without keyboard).

It's actually kind of impressive how poorly these computers perform, even often on apps that were specifically ported to the new platform, but if you really want to you can muddle through so let's talk about what's good. The first is the always-connected 5G internet. For anyone that constantly travels, the idea of having a permanent hotspot running in the background is amazingly convenient, and while we didn't actually purchase an eSim plan to test out for this feature, we're happy to assume one of the world's leading smartphone processor manufacturers is able to give its devices solid 5G connectivity. Add to this WiFi 6E which in congested environments can offer massively improved speeds.

The other major improvement is battery life, which offers over 14 hours of 1080p movie playback instead of the eight hours and 29 minutes you'll get from the Intel-based Surface Pro 9. While this is a positive, to put it in perspective you're getting around half the performance of a $1,499 M1 Apple MacBook Air (late 2020) if you opt for the $2,599 SQ3 Surface Pro 9. You'll also miss out on an extra five-ish hours of 1080p movie playback battery life.

This kind of a comparison is surely enough to make even the most diehard Microsoft fans consider jumping ship, and for those that will never you could just get a regular Surface Pro 9 and hotspot internet off your phone.

	Surface Pro 9 i7	Surface Pro 9 (SQ3, 5G)	Apple Macbook Air (M1, Late 2020)	Microsoft Surface Pro 8
Geekbench 5 - Single-core (score)	1,215	1,122	1,735	1,328
Geekbench 5 - Multi-core (score)	6,630	5,721	7,627	5,198
Cinebench R23 - CPU (multi-threaded)	6,891	3,699	7,588	5,246
3DMark - Time Spy (score)	1,779	898	NA	1,710
Geekbench 5 - Open CL (score)	17,905	NA	18,394	19,697
Battery life - 1080p video playback (h:min)	08:29	14:18	19:06	07:14
CrystalDiskMark Read (MB/s)	3,502	3,160	2,700	2,364
CrystalDiskMark Write (MB/s)	2,527	1,631	2,858	1,585

The 5G connected Surface Pro 9 makes us just want a regular 2-in-1.

Joel Burgess

★★☆☆☆

ULTRABOOK

Microsoft Surface Laptop 5

Is the fifth edition of the Surface Laptop worthy of another high-five for Microsoft?

■ $2,699 | microsoft.com/en-au

When you're updating a range of laptops frequently the level of change you can (or would want to) introduce to a device contracts, since many of the things consumers want are already included in the existing package. While this might make new devices less exciting, it's often actually a sign that a device has a lot going for it already, but it does mean that if the company gets one of the few things it updates wrong, it suddenly makes the entire update seem a bit futile.

Microsoft's New Surface Laptop 5 has the same 30 by 22 by 1.5cm profile, a similar 47Wh battery and a nearly identical 1.297kg weight as its predecessor the Surface Laptop 4. The 13.5-inch PixelSense multi-touch display is also the same and there's even the same WiFi 6 802.11ax compatibility – a disappointing retention that means the Surface Laptop 5 misses out on the newish, much faster WiFi 6E specification.

There are, however, a few major changes including the company ditching an AMD processor configuration (which it has offered for the last few years) in lieu of an all-Intel lineup. We suspect this was a commercial decision since the 15-inch Surface Laptop 4 with a Ryzen 7 4980U was the only AMD unit Microsoft was still selling at the time of writing. Ironically, this device actually outperformed this year's Intel processor in general home office benchmarks and battery life tests considerably, and even offered a bigger screen and was, arguably, a better overall value proposition. We guess you can't argue with what sells.

The Surface Laptop 5 comes in 13.5-inch and 15-inch configurations that start at $1,699 and $2,199,

■ W11 Home: 13.5-inch PixelSense display at 2256 x1504 pixel resolution; Intel Core i7-1255U CPU; 16GB RAM; Intel Iris Xe GPU; 512GB PCIe SSD; WiFi 6 802.11ax; 47Wh Battery (9h 12min 1080p movie playback); 30.8x22.3x1.45cm; 1.3kg.

respectively. While you can get a handful of 13.5-inch variants with a 12th generation Intel Core i5 processor, most of the consumer units offer a custom Intel Core i7-1255U CPU. The device we benchmarked featured the latter processor here with 16GB of RAM and a 512GB SK Hynix PCIe SSD. This SSD is one of the few improvements on the Surface Laptop 5 increasing the read and write speeds by about 1000 MB/s each to 3,399 and 2,285MB/s respectively. Even with the improvement though, it's still only around 50-percent of what you get on comparable 2022 ultrabooks like the HP Envy x360 2-in-1.

While the Surface Laptop 5 might be outperformed by last year's AMD powered device, it did show some improvements in multi-threaded CPU heavy workloads over the Intel-based Surface Pro 4 at least. There's also a roughly 20-percent improvement on graphical capabilities this year too, which means you'll be able to play slightly more games on 1080p low settings, but this won't be enough to tempt anyone to upgrade.

The only other major improvement we can see is the inclusion of a Thunderbolt compatible port for greater display versatility and power throughput options, so it's not exactly a revolutionary step forward. You can expect around eight or nine hours of battery life for light workloads or 1080p media playback. Much like everything else on this device, even though it's a sideways step in many ways, against other devices in the market it is still competitively priced.

	Surface Laptop 5	Surface Laptop 4 13"
PCMark 10 - Overall (score)	4,353	4,144
Geekbench 5 - Multi-core (score)	6,532	4,827
Cinebench R23 - CPU (multi-threaded)	7,626	3,681
3DMark - Time Spy (score)	1,796	1,505
Geekbench 5 - Open CL (score)	17,891	15,091
Battery life - 1080p video playback (h:min)	09:11	08:23
CrystalDiskMark Read (MB/s)	3,399	2,230
CrystalDiskMark Write (MB/s)	2,285	1,207

An underwhelming update to an already great consumer ultrabook.

Joel Burgess

★★★★☆

GAMING LAPTOP

Aorus 17

A performance-first gaming laptop that offers budget conscious gaming at pro levels.

■ $3,699 | gigabyte.com

The Aorus 17 from Gigabyte is your classic gaming rig: it's got a big fast screen, it's bulky and it's borderline a portable PC with how much battery life you get. That said, when it comes to gaming capabilities there's not much more you'd want and while nothing with a 3080 Ti GPU is going to ever be super affordable... the Aorus 17 is as cost efficient as you can make a high end gaming rig.

Aorus used to go in for all the premium high-end finishes you can think of but the last few years it's been angling more at the no-frills gaming laptop space. Despite this, we actually like the overall appearance of the 12th gen Aorus 17 maintaining a simple all-black exterior with a few chassis design choices that make it subtly still look like a gaming laptop.

The range is condensed to just three variations of GPU, but we could actually only find variants with either a 3070 Ti or a 3080 Ti locally. Prices for these units varied considerably too but the best price we saw for the 3070 Ti was $2,999 from Computer Alliance or $3,699 for the 3080 Ti version from Centre Com. The 3070 Ti pricing is competitive, but it's not overly easy to get a 3080 Ti gaming laptop for under $4K, so that's really competitive.

We tested the higher specced model with an Intel Core i7-12700H CPU, 32GB of RAM and a 1TB SSD. The Aorus 17 features a 1080p screen with a 360Hz refresh rate for pro-level competitive gaming. The colour is fine, but much like everything else that isn't performance focused here, HDR has been jettisoned.

■ W11 Home; 17.3-inch 360Hz IPS display at 1920 x 1080 pixel resolution; Intel Core i7-12700H CPU: Nvidia GeForce RTX 3080 Ti GPU; 32GB RAM; 1TB PCIe SSD; 99Wh battery (1h 34 min 1080p movie playback); 39.8x25.4x2.7cm; 2.7kg.

> "The Aorus 17 features a 1080p screen with a 360Hz refresh rate for pro-level competitive gaming."

Fortunately, this dogged focus means the Aorus 17 is actually pretty great at what it does. The i7-12700H is an excellent processor and the Aorus 17 has designed a cooling architecture that allows it to flourish equalling or beating a number of comparable devices. The 14 core processor will be more than enough to game exceptionally well for years to come and it'll excel at demanding working scenarios.

Graphically the Aorus 17 also did really well, keeping up with or outpacing many rigs with 3080 Ti GPUs running 165W or 175W power limits rather than the 130W maximum on this device. That translates to 80fps-plus on popular demanding games or 120fps and above on less intensive titles. The performance focus and components on this device mean it's well suited to pushing towards the screen's absurdly fast 360Hz refresh rate.

Battery life is only around an hour and a half, but that's to be expected for this kind of device. The keyboard is deep and springy, the trackpad is fine and it's got a webcam, microphones and speakers.

If you're after a device to seriously game on, and you don't care about the bells and whistles then this is a great option that cuts costs in all the right places.

	Aorus 17 YE4	Asus ROG Zephyrus Duo 16
PCMark 10 - Overall (score)	7,649	7,114
Cinebench R23 - CPU (Score)	13,932	14,275
Max CPU Temperature (C)	86	85
1080p movie playback (HH:MM)	01:34	02:50
3DMark Time Spy (score)	11,663	10,180
F1 2021 - 1080p Ultra (fps Av.)	122	117
CrystalDiskMark Read (MB/s)	6,999	6,552
CrystalDiskMark Write (MB/s)	4,999	4,399

An exceptional gaming unit for those that want perfect performance without paying too much for it.

Joel Burgess

★★★★★

EARBUDS

BOSE QUIETCOMFORT II

Ultra sound.

■ $429 | bose.com.au

There are an extraordinary range of earbuds available from a host of manufacturers, and we usually try to inform you about new models that offer great value for money – that is, affordable units that still sound superb. Here, however, you'll see that we're testing buds toward the top of the price scale. It's with good reason, though, because these are simply the best noise-cancelling earbuds that money can buy.

These earbuds have undergone a significant redesign. For starters, they are around a third smaller, which makes them more comfortable to wear than bulkier rivals, such as the Sony WF-1000XM4.The QuietComfort II's noise-cancellation feature is exceptional. We tested the buds in a crowded pub and, whether it was the loud conversations on the table next to us or background music pumped out from ceiling speakers, outside noise just didn't get in. They were just as good at blocking out noisy public-transport environments.

"These earbuds have undergone a significant redesign."

The quality of playback is also brilliant. We listened to a wide range of musical genres, from rap to classical, and the calibre of sound was consistently high across the board. Bose claims a battery life of up to six hours, with three extra charges coming courtesy of the charging case. It can fully charge the QC Earbuds II in one hour, with a 20-minute charge delivering around two hours of playtime. The case charges via USB cable only, meaning there's no wireless charging option.

A superb redesign for Bose's flagship earbuds, which sound better than ever and keep background noise at bay.

APC

★★★★★

■ Supports SBC and AAC codecs; USB-C charging; Bluetooth 5.3; 17.2x22.4x30.5mm; 6.2g per earbud; two-year warranty.

EARBUDS

SENNHEISER MOMENTUM TRUE WIRELESS 3

Unbeatable audio quality at the price.

■ $299 | sennheiser-hearing.com

The Sennheiser Momentum True Wireless 3 were released mid-way through 2022, and notably have just received a firmware update that addresses the most important shortcomings. Now, these buds support multipoint device connectivity – so, you could be listening to music on your laptop and with a single tap switch to your previously-paired phone. That brings them in line with its competitors.

The second upgrade is support for high-resolution sound mode featuring 24-bit depth and 96 kHz sample rate capability. It allows use of the aptX Adaptive codec, which has a bit rate of 420 kilobits per second. Usefully, they will switch back automatically to a lower bitrate if the environment has too much RF interference to function at the higher rate.

This latter upgrade propels the Momentum True Wireless 3's into the upper echelon of quality audio – and even before, they were already up there with the best. It's a very clean and pure sound, with clarity, refinement and spaciousness the order of the day. Bass is solid and punchy without being too thick or overwhelming. They suit all music types, and voice is particularly well defined for calls and audiobooks.

Comfort is good, and in particular they're very quick and easy to insert. I still struggle to get the Google Pixel Buds Pro properly positioned, and they're a similar design. The Senny's pop straight in and the seal is excellent. I wouldn't recommend them for the gym or running, though, as they're lacking the wings buds designed for that purpose have to hold things in place more reliably.

The True Wireless 3 keep the momentum going strong.

Ben Mansill

★★★★½

■ Supports SBC, AAC, aptX, aptX adaptive codecs; USB-C charging; Bluetooth 5.2; 5.8g per earbud; two-year warranty.

SMARTPHONE

MOTOROLA MOTO G82 5G

Gee up.

■ $399 | motorola.com.au

For many years, Moto G models were a straightforward recommendation for anyone looking for an Android smartphone at a reasonable price. However, the essence of the old Moto G spirit lives on in this G82 5G device. It's a sensible, reliable and uncluttered phone that comes with a fairly large OLED screen, 5G mobile coverage, a generous amount of storage and stereo speakers – all at an appealing price.

With its plastic case this isn't a particularly attractive phone, but its design is pragmatic and simple. The screen is a 6.6in 120Hz OLED panel, which is the kind of specification we'd want to see at this price because it offers high levels of contrast.

The phone runs Android 12 with the traditional Moto interface. This makes fairly light changes to Google's operating system, including a few tweaks to the look and feel of dropdown menus. There's also a new Peek Display information screen, which appears when you pick up the phone after it's been asleep, providing an at-a-glance view of the time and battery life.

Android 12 feels pretty slick, although app loading and multi-tasking will seem marginally slower than on an upmarket Android phone. The G82 5G uses the Qualcomm Snapdragon 695 processor, a mid-range chip. This means some graphics settings won't be available in more demanding games, which may also suffer from patchy frame rates. The camera is a tad disappointing, with the main unit proving adequate in good light but poor in low light, resulting in blurring and grainy effects.

A decent Android smartphone, but there are alternatives that offer more for a similar price.

APC

★★★★☆

■ Eight-core Qualcomm Snapdragon 695 processor; 6GB RAM; 128GB storage; 6.6in 120Hz 2400x1080-pixel OLED screen; 50-megapixel rear camera; 8-megapixel wide camera; Wi-Fi 5; Bluetooth 5.1; Android 12; 161x74x8mm (HxWxD); 173g; one-year warranty.

POWER SUPPLY

THERMALTAKE TOUGHPOWER GF3 1200W ATX V3.0

Tops our performance chart.

■ $399 | thermaltake.com.au

The Thermaltake Toughpower GF3 1200W offers high performance and compatibility with ATX v3.0 and PCIe 5.0. Thermaltake recently introduced its GF3 line, starting from 750W and going all the way up to 1,650W. There is no need for an ATX v3.0- or PCIe 5.0-ready for the new RTX 4000 or Radeon 7900 cards. You just need a strong PSU, ideally 1,000W or more powerful. But, if you want to avoid adapters and be future-proof, a PSU like the GF3 1200 is the way to go.

The Toughpower GF3 1200W has a native 12VHPWR connector, and it is ATX v3.0 compatible, meaning that it can deliver double its power, 2,400W, for 0.1ms periods without shutting down or having any other operating issues. This is to cope with any power spikes from the GPU or any other system component. Thermaltake also equipped it with a fluid dynamic bearing fan and other top-quality parts, which should allow it to outlive the extended, ten-year warranty.

The cables are long, and the distance between the peripheral connectors is adequate. The Thermaltake Toughpower GF3 1200 is a solid platform which offers high performance in almost all areas. The unit's transient response, among the critical performance factors, is great and the same goes for ripple suppression. If only the fan speed profile were less aggressive, but the lack of heat sinks on the 12V board, and the extended warranty probably pushed TT to tune the fan speed profile.

The price difference is quite significant to justify ATX v3.0 and PCIe 5.0 compatibility, but if you want to be as future-proof as possible, you will have to pay for it.

The Thermaltake Toughpower GF3 1200W is powerful and comes with a 600W 12VHPWR connector, supporting all current and upcoming GPUs.

Aris Mpitziopoulos & Ben Mansill

★★★★☆

KEYBOARD

CORSAIR K70 PRO MINI WIRELESS

Exchange keys.

■ $209 | corsair.com

There's no denying that $210 is a lot to pay for a keyboard, particularly a small one that doesn't come with a number pad. The reason for this premium price is that you can customise this wireless keyboard in brilliant ways.

For example, the mechanical Cherry MX Red switches located under the keys can be exchanged if you wish. That means that should a key wear out or malfunction, it's a simple matter of unclipping the key cap and replacing the switch. And should you tire of the feel of the keys when typing, you could even install different switches across the entire keyboard.

Corsair supplies an app that lets you control everything about the way the keyboard works, from the specific hue of its backlighting to customised macros you can set up and use.

If you share a PC, you can even set up different profiles, and any settings can be remembered should you connect it to another device. It works either via Bluetooth; a supplied 2.4GHz wireless dongle (which can be clipped on to the keyboard for storage when not in use); or cable via USB-C. The latter guarantees the fastest connection, which gamers will appreciate, while Bluetooth will benefit battery life (around 200 hours). The 2.4GHz option sits somewhere between the two.

> "The mechanical Cherry MX Red switches located under the keys can be exchanged if you wish."

There are cheaper wireless mechanical keyboards available, but we haven't seen any that you can customise like this.

A highly customisable wireless keyboard that accommodates your preferences, but it's expensive.

APC

★★★★☆

■ USB-C; 2.4GHz wireless dongle; Bluetooth 4.2; Cherry MX Red switches; 67x307x108mm; 64g; two-year warranty.

SOLID-STATE DRIVE

PNY ELITEX-PRO 1TB

Up to speed.

■ $179 | pny.com

Many laptops are still a little light in the storage department. 256GB is about the minimum we'd recommend as your main drive for installing Windows on, though you'd still find SSDs as small as 128GB in the cheapest laptops until recently. If you're saddled with insufficient storage, an external drive is a sensible option.

> "If you're saddled with insufficient storage, an external drive is a sensible option."

This particular model is a 1TB portable SSD that connects to a laptop via a USB-C or standard USB port. It doesn't support the fastest Thunderbolt standards, so it's worth looking for a model that does if you have a Thunderbolt-compatible port (look for the lightning bolt symbol on the port). For anyone else this is a nippy, affordable storage solution.

It comes in four capacities (500GB, 1TB, 2TB and 4TB), but the 1TB version we've reviewed here costs $179, which is good value for money, even though the $239 2TB model offers the best value in terms of cost per gigabyte.

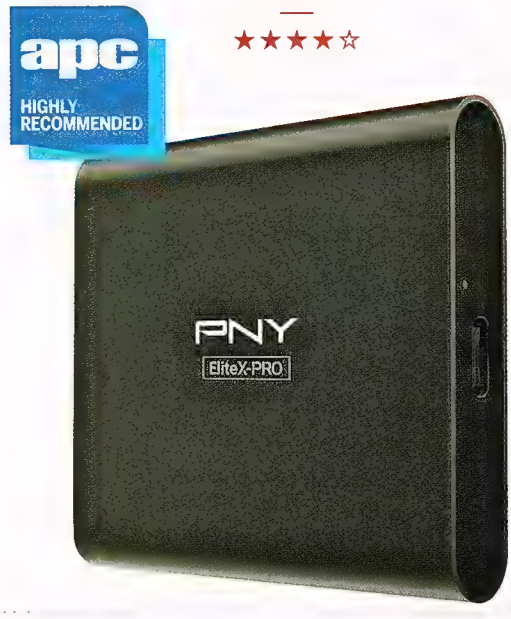
It has a black aluminium case that's topped and tailed with black plastic. There's a USB-C port at one end, along with an LED to show you when the drive is operating. It comes with two cables, which connect the drive to either USB-C or a standard USB 3.0 port on your PC.

In tests we saw read speeds of up to 1.69Gbps and write speeds of 1.61Gbps. This is a solid return for a non-Thunderbolt drive, and should be able to handle any job you throw at it, including running installed software.

A fast, portable SSD that's ideal for PCs running low on storage or that travel a lot.

APC

★★★★☆



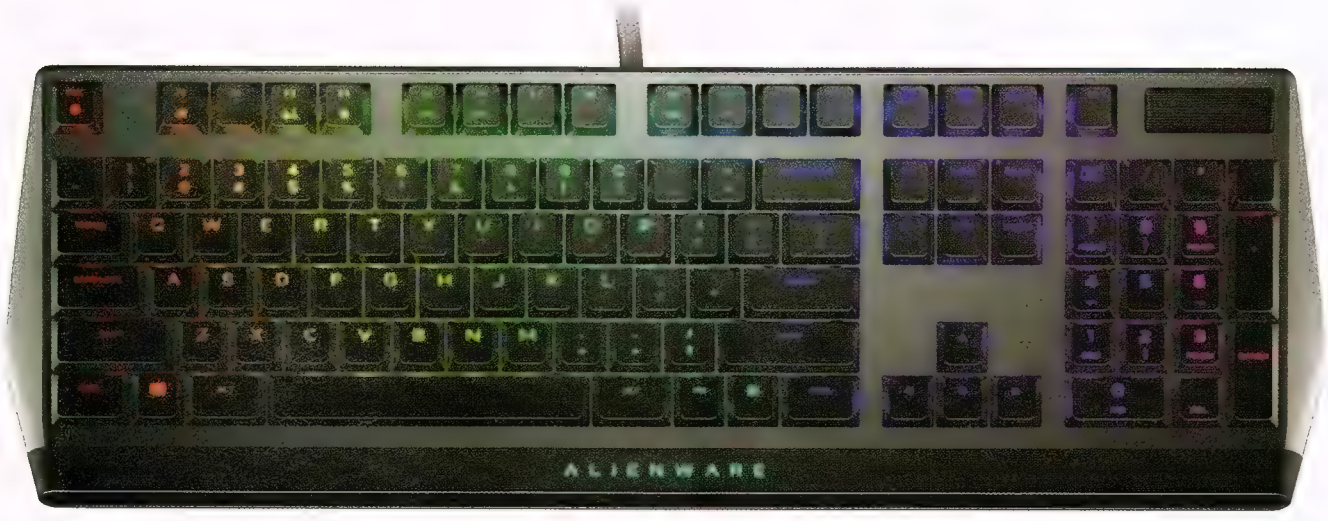
■ USB-C port; USB-C and USB 3.0 cables provided; 500GB, 1TB, 2TB or 4TB capacities; 11x65x58mm; 105g; three-year warranty.

GAMING KEYBOARD

Alienware 510K

Low profile with a high price tag.

■ $258.50 | www.dell.com



It's no secret that keyboards are creeping up in price, and the Alienware 510K definitely falls into the pricier end of the spectrum. For $258.50 you're getting a full sized mechanical keyboard with low profile Cherry switches and passthrough, but does it have enough bells and whistles to justify the price?

Right out of the box, the keyboard feels very light. It only weighs 910g and, at first glance, it looks a little odd – that's because the shape of it isn't typical of most other keyboards with some pointed outer edges towards the bottom. This gives the keyboard some additional stability, especially when it's up on an angle, but it's not really noticeably different to typically rectangular keyboards. Once it's plugged in and lights up however, it puts on quite a stunning display, with the RGB backlighting really shining through thanks to the design of the 510K's keycaps.

There's a stack of customisable options for the 510K. Directly on the board itself you can adjust the brightness of the backlighting, but if you want even more control you'll need to download Alienware Control Centre. From there, you can adjust how the keyboard lights up with a full colour spectrum and sequence settings and even adjust the programming of your keys.

Completely wired, the 510K also offers a passthrough option. You'll still need to use an additional USB port on your PC, but with its 2m braided cord it definitely helps with cord management for your other peripherals. There's also a volume wheel in the top right corner of the board, with an extra mute key so you can control your PC's volume with ease. The rest of the keys are placed into a typical layout with three different sections for the letters, the middle arrows and the numpad, so the overall design and feel of the board is very familiar and is simple to get started on.

> "There's a stack of customisable options for the 510K."

Technically, the 510K has a lot to offer. Our review model came with Cherry Red low profile switches, and they perform brilliantly. Silent and with nice haptics thanks to a smooth pushback, the feeling of typing on this board is delightful – especially if you're a fan of low profile keys. The switches also have a low actuation force, so you don't have to press down hard on the keys to get a response. It's comfortable too, with a total of four feet – two different sizes on either side – under the keyboard giving it three different angles so you can set it up in a position that's most comfortable for you.

All in all, if you're looking to move from a membrane keyboard to your first mechanical keyboard, the Alienware 510K will give you that familiarity along with great performance, just know you'll be forking out quite a lot of money. Sure, the programmable lighting is nice, and the low profile switches perform extremely well, but these features aren't unique to the Alienware 510K.

The 510K is a bit pricey, but has plenty of features and customisation options.

Petra Cranshure-Player

★★★½☆

Windows 7, 8.1, 10 or 11, .NET Framework 4.5 | Free | patchmypc.com/home-updater

PATCH MY PC HOME UPDATER 4.5

The easy way to keep your system fresh.

It's important to keep the software on your PC up to date, both to fix bugs and security vulnerabilities, and to ensure you have access to the latest features. But while some programs – such as browsers – automatically install new versions as soon as they're available, others need to be updated manually. Patch My PC makes this task much easier by letting you update more than 300 popular tools in one go.

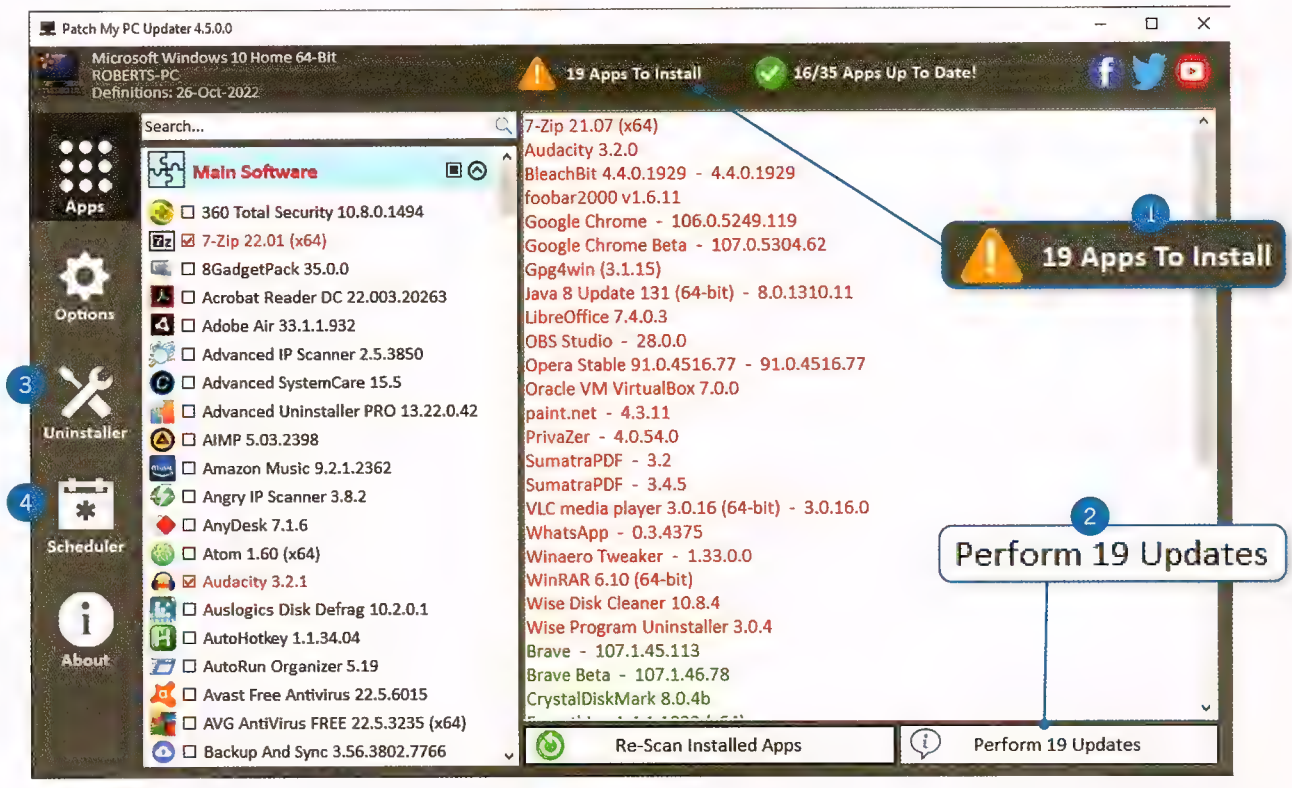
Download and run Patch My PC Home Updater (it doesn't require installation) and you'll be presented with a list of all the programs installed on your computer, plus others in the software's database. Previously, these were organised into categories such as Browsers, Multimedia and Utilities, but version 4.5 simplifies the presentation by using a single alphabetical list labelled Main Software and another for Portable Software.

Outdated versions of programs are highlighted in red, while up-to-date ones are marked in green. To save you time, Patch My PC now lets you click the checkbox in the top-right corner of the list twice to select all the tools that require updating (clicking it once selects every tool). Click the 'Perform [x] Updates' button in the bottom-right corner of the window to download and install the required updates. You can also install programs you don't already have by selecting them in the list and clicking Perform Updates, and remove unwanted tools by clicking Uninstaller.

> "To save you time, Patch My PC now lets you click the checkbox in the top-right corner of the list twice to select all the tools that require updating."

Patch My PC Home Updater 4.5 improves its detection of software including Opera, Malwarebytes, ProtonVPN and Sumatra PDF, while dropping support for discontinued tools such as Adobe Flash Player. It also helps you find programs faster by pressing Ctrl-F to jump to the search box.

Particularly useful is the option to check for available updates at a frequency of your choice – click Scheduler to specify how often, from once a day to once a month, and set your other preferences, then click Save Custom Schedule.



1 Double-click the checkbox in the top-right corner of the Main Software or Portable Software list to select all the programs on your PC that need updating. Patch My PC will highlight them in red and tell you how many apps it will install.

2 Click the 'Perform [x] Updates' button to download and install the required updates. Click 'Cancel Updates' if you change your mind. Click the Re-Scan Installed Apps button to ensure that all your programs are now up to date.

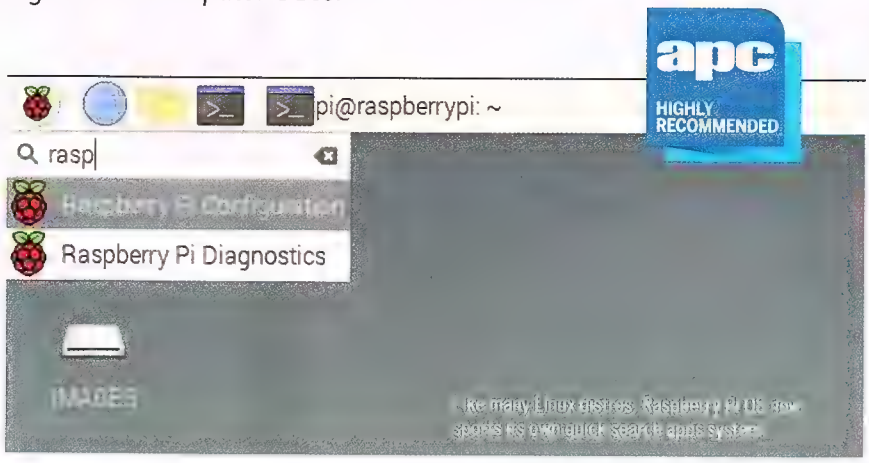
3 Patch My PC can also uninstall unwanted software. Click the Uninstaller tab, select a tool to remove in the right-hand panel and click the Uninstall button. Right-click a program and choose Remove Program Entry to delete its registry key.

4 Click the Scheduler button to install software updates automatically at the frequency and time of your choice. Click 'Save Custom Schedule' to create a scheduled task or choose Save Suggested Schedule to use Patch My PC's default settings.

Various licences available | www.raspberrypi.com/software

RASPBERRY PI OS 09.22

Les Pounder explores the latest Raspberry Pi OS in a decade of releases that saw it become the gold standard for single-board computer OSes.



The latest Raspberry Pi OS 32-bit update has landed, with little fanfare and just a smattering of new features. Let's cut to the chase: it's more of a bug fix and update of included software. That said, the release is well implemented and we see new features such as a searchable main menu. If you favour keyboard shortcuts over the mouse, pressing the Super (Windows) key and typing in an application name will bring you great joy. This leads nicely into new keyboard shortcuts for Bluetooth (Ctrl-Alt-B) and Wi-Fi (Ctrl-Alt-W) menus.

An interesting new feature is audio control. Gone is the unified controller for input and output, and in its place we find two icons for input and output. Right-clicking on the input icon enables us to change inputs, including Bluetooth microphones. The same is true for the output.

Using Raspberry Pi OS as a daily driver is possible – with a 4-8GB Raspberry Pi 4 you could happily use the web browser or code your next project. YouTube video playback is still a mixed bag. If you must go full-screen, stick to 720p and forget about 60fps video. Local video playback is fine, aided by the Pi's VideoCore GPU.

The release also sees the latest iteration of Picamera, the Python module used to interact with the official Pi cameras. The latest version, Picamera V2, is no longer a community maintained project created by Dave Jones – development has moved in house. Previous versions of Picamera wouldn't work with the latest Raspberry Pi OS releases, forcing Raspberry Pi to release a legacy OS as a stopgap. Picamera V2 is still in beta, and is based on an open framework with libcamera at the core. Picamera V2 feels very similar to the original, so converting code from one to the other is simple. The API is easy to use and it uses OpenGL acceleration for better performance. Audio and video can now be recorded, which was tricky with the older Picamera module. If machine learning and AI are more your thing, Picamera V2 works with numpy and tensorflow to identify objects based on models.

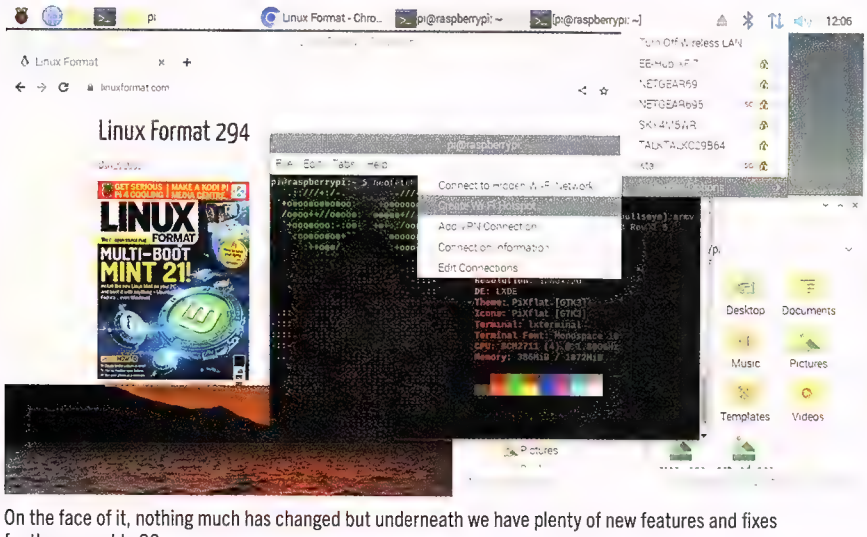
> "Using Raspberry Pi OS as a daily driver is possible – with a 4-8GB Raspberry Pi 4 you could happily use the web browser or code your next project. "

Hidden in the Raspi-config menu is a means to change how we manage our networking. In the past, dhcpcd was used to make (and break) wireless and wired connections. Arriving as a beta, NetworkManager is now offered as an alternative and it's already quite impressive. We can do the usual connection management, manage VPNs and connect to hidden SSIDs, but we can now turn our spare Raspberry Pis into Wi-Fi access points. This was previously possible if you were comfortable with the terminal, but with NetworkManager we can do all of this from a pleasant GUI interface.

Everything else is just business as usual, with GPIO access remaining the same. It is great to receive the bug fixes and updates, but isn't it time that Raspberry Pi switched to a 64-bit OS? After all, we've had 64-bit capable boards since the Raspberry Pi 3 arrived in 2016.

Raspberry Pi OS feels smoother and more 'desktop' than previous releases, thanks to a bug fix that removed an annoying 100 percent CPU usage in the file manager.

Raspberry Pi OS is still the standard against which other single-board computer OSes are measured, and in the first decade of Raspberry Pi, it is great to see how far it has come. Raspberry Pi OS is now a competent operating system. With a Raspberry Pi 4, 400, Compute Module 4 or even the Raspberry Pi Zero 2 W, you have plenty of power to push the OS forwards.

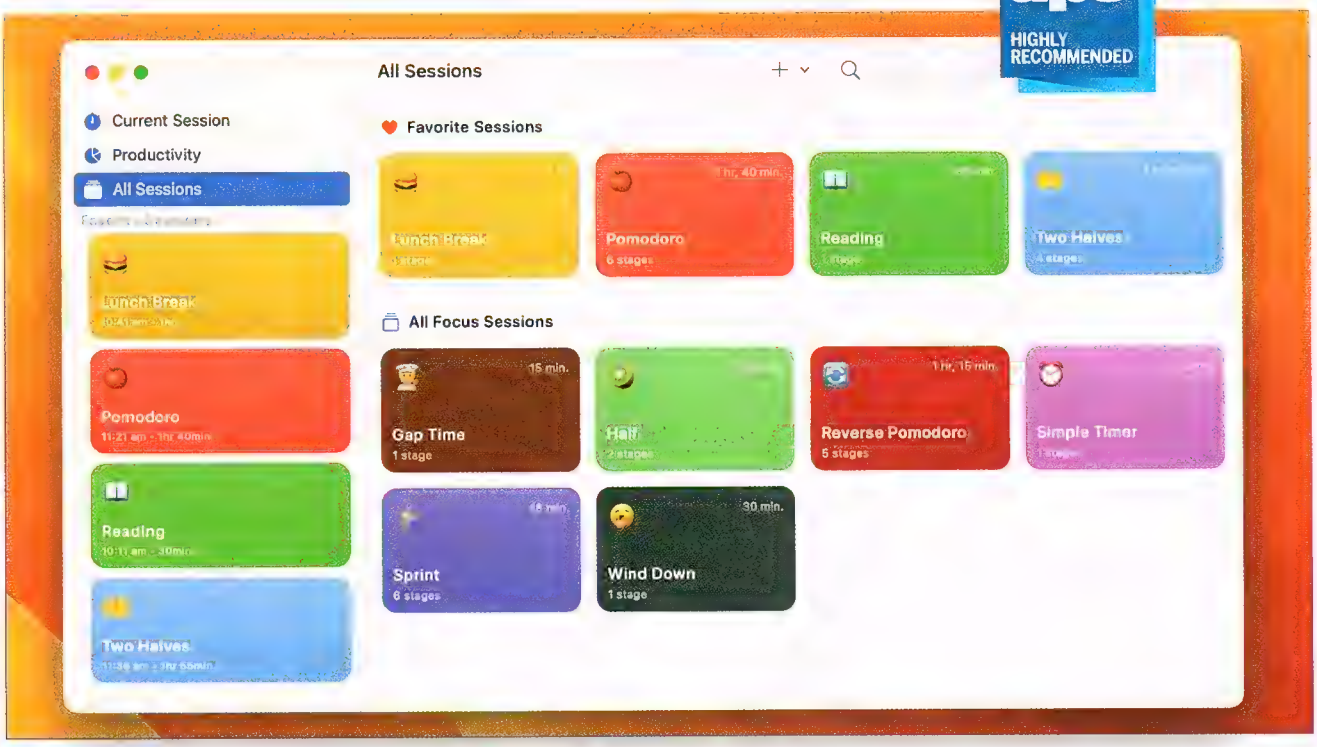


On the face of it, nothing much has changed but underneath we have plenty of new features and fixes for the venerable OS.

On the surface, nothing much has changed, but under the hood, Raspberry Pi OS has received a much-needed update.

Les Pounder

★★★★☆



macOS 12 or later | (Pro subscription $7.99/month, $47.99/year, $89.99 lifetime) | focusedwork.app

FOCUSED WORK 3

Work more efficiently without distractions.

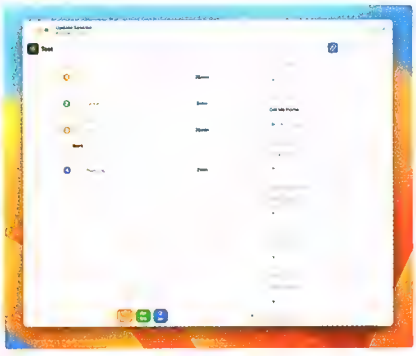
Above: The clear interface makes it super-easy to keep on top of your sessions and can be customised to work your way.

Focused Work is an app that's designed to help you with two problems related to working on your Mac. The first is when you can find yourself distracted by things like social media and become less productive. The second and somewhat opposite problem is when you work too hard for too long, causing a sense of burnout. Michael Tigas developed the app to help with his own working methods and a desire to be more productive. Running on your Mac but also syncing to iOS versions of the app via iCloud, it is not as you might perhaps expect an app that 'blacks out' your screen and shows you just the app you are working with. Rather, it's a sort of advanced scheduler that notifies you and runs actions at predetermined times.

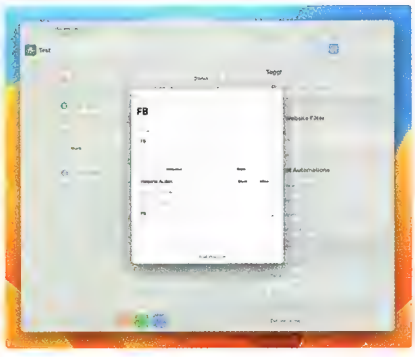
You start by creating a session and within that, adding blocks of time that can be assigned as either work, break or planning. The Session Creator Tool is at the heart of the app and has been upgraded since version 2, making it more powerful and easier to use. Within a session you can add different kinds of actions such as running shortcuts when work or break times start or end, sending yourself reminders, using Toggl to keep a record of each session and triggering the macOS Focus states.

You can also specify individual websites or apps to block during a running session, which will stop you drifting on to social media or chatting online. While it may

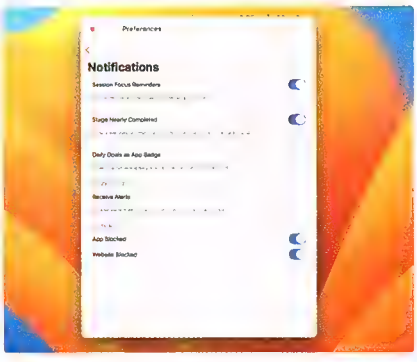
APP TIPS GET STARTED WITH FOCUSED WORK 3



You can set shortcuts to run at specific points. For example, when ending a session, get Maps to calculate your route home.



A session can block specific websites or apps while running, as chosen and set up by you. This helps remove distractions while working.



The app can send you all kinds of time-based reminders, though these can be selectively muted in the Preferences if you prefer.

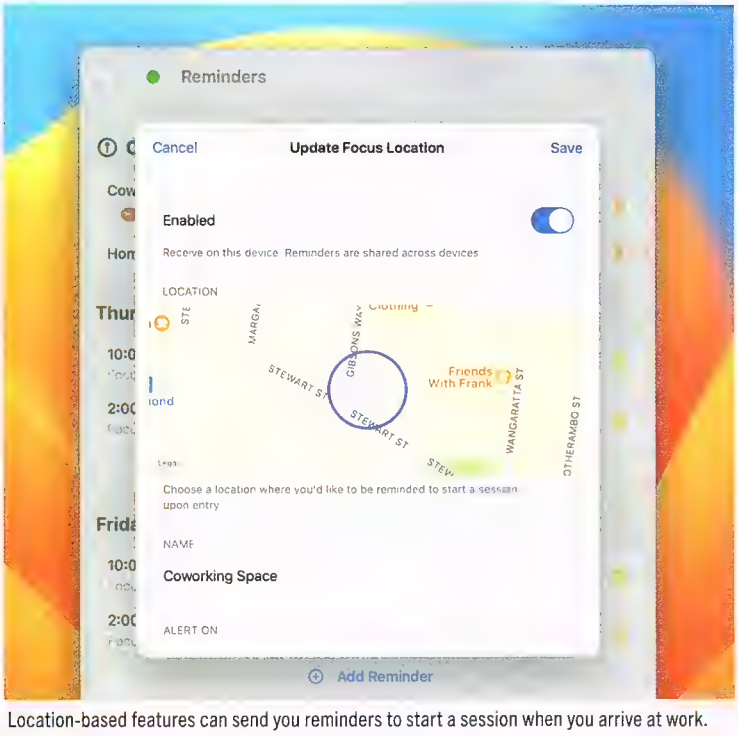
sound odd to have to self-censor in this way, many people would admit to checking their feed pretty regularly when they're supposed to be working. The app is free to download but many features such as creating multiple sessions and blocking are only available after paying to unlock.

Remind and assign

A running session appears as a counter window that can be set to count down or up and that mystifyingly has a ticking noise on by default – what could be more distracting? – though this is easy to turn off globally. In addition to telling you when to take a break, and perhaps running actions at those times, say, reminding you to email someone or go outside for some air, it can be used as a way of organising your day.

You can assign names to each block of time, breaking the day into smaller tasks, which is generally held to be a good way of achieving things more efficiently. You can keep track of your productivity over time as well as setting location-specific triggers, when you arrive at work, for example.

Focused Work is capable of very granular and advanced time management and notifications and it's easy to set up and use, especially if you save a few templates to suit your work day. Not everyone will need such micro-managed nudging and some types of work benefit more from breaking into chunks of time than do others. That said, even those who prefer a more freeform working day will benefit from a little structure, and the ability to pre-block distractions. Ultimately, it could train you into a more productive way of working.



Location-based features can send you reminders to start a session when you arrive at work.

You can keep track of your productivity over time with statistics about time worked, breaks taken and the like.

A simple but powerful time-management and focus app.

Hollin Jones

★★★★☆

FEATURE

AMD Radeon RX 7900 XT & 7900 XTX

AMD is fighting the good fight, as Chris Szewczyk discovers.

AMD's much hyped third generation RDNA architecture is here! And it's an exciting one. The Radeon RX 7900 XT and 7900 XTX are here to take the fight to Nvidia. With a launch price of $1,619 for the RX 7900 XT and $1,789 for the RX 7900 XTX, The're halo products priced above what most mainstream gamers are willing to pay, though notably both are priced well below the RTX 4080, which starts from about $2,199.

Under the hood

Both cards are built around the Navi 31 GPU, the first to feature the new RDNA 3 architecture. But this isn't just another GPU on a smaller node with some tweaks, higher clocks and more shaders. It comes with a chiplet-based architecture. Though not the first chiplet GPU, it is the first one designed for graphics applications. Revolutionary is a word that gets thrown around too much, but in this case it's true. There are several commercial and technical reasons for adopting this approach.

Chiplets ahoy

On the technical side, the use of chiplets allow AMD to better optimise different parts of the GPU. With that in mind, AMD split off components such as the Infinity Cache and memory controllers into six separate relatively tiny 37mm² 6nm dies. They're called the MCDs, or memory cache dies. The scalable parts including the shaders are contained on the single 300mm² 5nm GCD, or Graphics Compute Die. It allows AMD to operate different parts of the GPU at different clock speeds and voltages, helping power efficiency.

The GCD contains six shader engines,

each with 16 compute units for up to 96 in total, with 6,144 dual issue stream processors. Each CU has a single Ray Accelerator and dual AI Accelerators. The 7900 XTX comes with all 96 CUs enabled, giving it 96 Ray Accelerators and 192 AI Accelerators. The 7900 XT has 84 out of the 96 CUs enabled, giving it 5,376 stream processors, 84 Ray Accelerators and 168 AI Accelerators. One of the six MCDs is also disabled for the XT. The full package contains 58 billion transistors.

Future scalability

The use of chiplets allows AMD to apply a modular approach across many different SKUs, even down to the entry level, eventually saving it a lot of money and effort that would go into developing multiple monolithic chips for different cards at wildly different price points. We'll have to wait and see what plans AMD has for its mid-range Navi 32 and 33 GPUswhich are to come later in 2023.

Dividing up a GPU into chiplets is a heck of an engineering effort, but perhaps the biggest challenge is to get them to efficiently talk to each other without incurring a latency penalty, which is critical for a gaming GPU. AMD had to dramatically scale the interconnect, so much so that it can handle up to 5.4 TB/s of bandwidth with what it claims is a negligible latency penalty.

The other advantage of a chiplet design is to increase chip yields, giving AMD more usable chips per wafer. This helps AMD to lower costs by leveraging the advanced (and more expensive) 5nm node for the parts of the GPU that benefit the most. When all is considered, RDNA 3 promises higher performance, better performance per watt, a more advanced feature set and more emphasis on ray tracing performance.

"We've got AMD's Radeon RX 7900 XT and RX 7900 XTX reference cards in the lab. They're joined by Sapphire's Nitro+ Radeon RX 7900 XTX Vapor-X. Can they compete with the RTX 4080?"

Tracing rays

As ray tracing is becoming an integral part of gaming graphics, ray tracing was an area of focus for AMD. An improved algorithm, stack management optimisations and larger caches help Navi 31 deliver a claimed 1.8x performance uplift over RDNA 2. But the 6000 series weren't great at RT anyway, and Nvidia remains a generation ahead.

The memory subsystem has been significantly improved. Where the 6900/6950 XT featured a 256-bit bus, the 7900 XT has a 320 -bit bus while the XTX has a 384-bit. Along with the use of faster 20Gbps GDDR6 memory, the XTX has up to 960GB/s of memory bandwidth, the XT has 800GB/s while the 6950 XT has 576GB/s.

Power and cooling

Prior to the RDNA 3 launch, AMD touted a lofty 50 percent performance per watt uplift. AMD resisted the brute force approach of chasing performance at any cost, though total board power has taken a step up. The RX 7900 XTX is rated at 355W, while the RX 7900 XT comes in at 315 W. This means cooling solutions don't need to be as extreme as some of those we've seen on the Nvidia side. Board partners are free to do as they please with both though. As we see with the Sapphire Nitro+ 7900 XTX.

Notably, AMD stayed with traditional 8-pin PCIe power connectors. Cheekily, AMD was happy to have a laugh at Nvidia's expense, following some isolated reports of 12VHPWR connectors melting. Several partner cards come with 3x 8-pin connectors.

RDNA 3 GPUs introduce DisplayPort 2.1 support for the first time. This means the cards support up to 8K at 165Hz or 4K at up to 480Hz. That alone is a notable advantage over the RTX 40 series, which is limited to DP 1.4. The reference cards come with a USB Type-C connection with DP tunneling support too. Monitors in the years to come will progressively add DP 2.1 support. Fancy a 240Hz 7680 x 2160 Ultrawide? Well, so do we.

Navi 31 offers dual AV1 encode and decode support, allowing two independent video streams to be processed concurrently. The cards have the ability to cooperate with the newly introduced integrated graphics of its Ryzen 7000 desktop processors. These features will come in handy for streamers using software such as OBS.

Tricks, features and testing

AMD is working on some interesting software features too. Its 3rd generation FidelityFX Super Resolution (FSR 3.0) technology is coming in 2023. Upscaling technology is becoming an integral feature of the graphics landscape. Will it include some kind of frame generation technology like DLSS has? We'll have to wait and see. AMD promises up to 2x the frame rate compared to FSR 2.0.

To the Labs!

We've got AMD's Radeon RX 7900 XT and RX 7900 XTX reference cards in the lab. They're joined by Sapphire's Nitro+ Radeon RX 7900 XTX Vapor-X. Can they compete with the RTX 4080? Are there some surprises to be revealed? Read on as we take a look at AMD's 2023 flagship fighters. And in the process, we're likely to set an APC record for the most X's in a single article, and we didn't even ask XFX for a card.

GRAPHICS CARD

AMD Radeon RX 7900 XTX

Team Radeon roars back into the game.

■ $1,789 | www.amd.com

■ AMD Radeon RX 7900 XTX; 6,144 stream processors; 2,499MHz boost clock; 24GB GDDR6 20Gbps memory, 960GB/s memory bandwidth; 2x DisplayPort 2.1, 1x HDMI 2.1a, 1x USB Type-C; 355W TDP; 2x 8-Pin power connectors.

The Radeon RX 7900 XTX naming hearkens back to the ATI days, where refreshes and die shrinks sometimes came twice a year. Technology has changed a lot over the last 20 years. Prices have gone up a lot, but so has the performance – by orders of magnitude.

The $1,789 XTX is well positioned in the market. It's significantly cheaper than the competing RTX 4080, though it's a little too close to the XT, which hurts that cards' position in the market. Even if it offers relatively good value, the XTX is still very much a high-end card, and out of reach of most gamers. Nevertheless, it incorporates that cutting edge chiplet technology and is squarely aimed at 4K gamers or users of very high refresh rate monitors.

"As a flagship card, the 7900 XTX needs to perform, and it does."

The RX 7900 XTX features the fully enabled Navi 31 chip, meaning all 96 GCD compute units are enabled, and all six MCDs. This gives it 6,144 shader processors, 96 Ray Accelerators and 192 AI processors. It packs in 24GB of 20Gbps GDDR6 memory over a 384-bit interface, providing a total of 960 GB/s of memory bandwidth.

The XTX is a little longer and a little taller than the XT. Its fans are larger too at 84mm versus the 78mm of the XT. It's a 2.5 slot card, meaning it's effectively three slots. The look is similar too, with a tasteful black finish with a few touches or red. The XTX includes a little bit of RGB lighting too. Interestingly, the XTX includes a fan intake temperature sensor. Though of limited use right now, this could be useful for synchronising with adjacent fans for example.

The PCB is slightly taller than that of the XT. It includes a 17+3 phase VRM with 70A stages. The TDP is 355W, meaning the card stays within the capabilities of its dual 8-pin PCIe power connectors. Video outputs consist of dual DP 2.1, HDMI 2.1 and USB-C outputs.

A peak temperature of 67 degrees for a compact 355W card is excellent. The cooler is clearly a good one. Power consumption was a little lower than expected. Given the big power consumption increase of the Sapphire Nitro+, the reference card appears power constrained.

As a flagship card, the 7900 XTX needs to perform, and it does, though there's always the asterisk next to ray tracing performance, where AMD is still a generation behind. In games like *Warhammer III and Ghost Recon: Breakpoint*, the XTX easily pulls ahead of the RTX 4080, even closing in on the mighty RTX 4090. Its RT performance is improved, matching the last gen, but the likes of *Cyberpunk 2077* with all the eye candy remain an Nvidia strength. It remains to be seen whether AMD can match the ever improving DLSS with its FSR 3.0 technology, coming in 2023.

The RX 7900 XTX is an excellent RDNA 3 debut for AMD. It offers better than RTX 4080 raster performance at a lower price, with superior display connectivity on top. It offers reasonable power efficiency and it's a better buy than the XT. Keep an eye out for the partner cards, which look to really unleash the Navi 31 GPU, albeit with higher power consumption.

The RX 7900 XTX delivers fast and efficient performance, but it feels a little power constrained compared to the Sapphire.

Chris Szewczyk

★★★★☆

GRAPHICS CARD

AMD Radeon RX 7900 XT

The little brother that misses out on all the attention.

■ $1,619 | www.amd.com

■ AMD Radeon RX 7900 XT; 5,376 stream processors; 2,394MHz boost clock; 20GB GDDR6 20Gbps memory, 800GB/s memory bandwidth; 2x DisplayPort 2.1, 1x HDMI 2.1a, 1x USB Type-C; 300W TDP; 2x 8-Pin power connectors.

The Radeon RX 7900 XT is the more affordable of the two RDNA 3 cards. It's based on a trimmed down variant of the Navi 31 GPU. It's priced at $1,619, which – relatively – isn't too bad.

The RX 7900 XT has 84 out of the maximum possible 96 GCD compute units enabled plus five out of six MCDs. This gives it 5,376 shader processors, 84 Ray Accelerators and 168 AI processors. There's 20GB of 20Gbps GDDR6 memory over a 320-bit interface, which delivers 800 GB/s of memory bandwidth.

After testing several of Nvidia's gargantuan RTX 4090 and 4080 models, the 7900 XT seems small in comparison! It's still a 2.x slot card – effectively a triple slot, but it's the height that gives it its smaller appearance. It's almost small form factor friendly. Almost. We think it looks great, with a mostly black finish with some splashes of Radeon red. There are three red coloured fins on the side to denote the third RDNA generation.

The cooler is a very efficient and compact vapour chamber design. The memory and VRM are cooled by a separate metal assembly with plenty of cooling pads for the memory and VRM circuitry. A full cover backplate protects the rear of the card. Overall the cooler and card are very well built. The idea that reference cards are the generic ones in a given family doesn't really apply anymore.

> "How does it perform? Generally, very well, and a big step up over the previous generation offerings."

The cooler performs well. We saw a peak temperature of just 60 degrees which is outstanding given the card lacks the sheer surface area of the bigger coolers. It becomes audible under load, sure, but these cards are so much better than the leaf blower cards of old.

The PCB is quite large, extending the length of the card. The GPU is powered by a 14+3 phase VRM with 70a stages. With a 315W TDP, the 7900 XT doesn't require more than dual 8-pin PCIe power connectors. They can provide 300W, while the card can pull another 75W from the slot. The card comes with dual DP 2.1, HDMI 2.1 and USB-C outputs.

How does it perform? Generally, very well, and a big step up over the previous generation offerings. Though both RX 7900's can't match the RTX 4080 in ray tracing, they do well in traditional rendering, sometimes beating the 4080, while matching Nvidia's last gen at ray tracing at a lower cost and power budget. But performance and relative efficiency are not the XT's problem. Its price positioning relative to the XTX is.

Ahh, price. How often do we talk about it? At $1,619, the card is only $170 cheaper than the XTX. That makes it tough to recommend because if you're spending $1,600+ already, $200 extra isn't a huge jump and the extra performance of the XTX is worth the money. But the real competition for the 7900 XT is going to be the upcoming RTX 4070 Ti. If AMD sees fit to drop the price of the XT, then its revised price and performance relative to the 4070 Ti will ultimately determine the 7900 XT's true standing in the market.

The RX 7900 XT is a fast and efficient offering but the XTX is the smarter buy for just 10 percent more.

Chris Szewczyk

★★★½☆

GRAPHICS CARD

Sapphire Nitro+ Radeon RX 7900 XTX Vapor-X

RX 7900 XTX unleashed.

■ $TBD | www.sapphiretech.com

■ Sapphire Nitro+ Radeon RX 7900 XTX Vapor-X; 6,144 stream processors; 2,680MHz boost clock; 24GB GDDR6 20Gbps memory, 960GB/s memory bandwidth; 2x DisplayPort 2.1, 2x HDMI 2.1a; 420W TDP; 3x 8-Pin power connectors.

During our testing of the reference RTX 7900 XTX, we believe it to be power constrained, preventing it from reaching its full performance potential, likely a deliberate characteristic to preserve efficiency. That doesn't apply to the mighty Sapphire Nitro+ Radeon RX 7900 XTX Vapor-X. In every way, it's bigger and brawnier than the reference card. It really looks impressive.

The Nitro+ features Sapphire's stunning 3.5 slot Pantheon cooling solution. Its matte grey finish is minimalistic but beautiful in look and feel. Among its many features are the Vapor-X vapour chamber, wave fins for reducing noise, a die cast aluminium front plate for VRM cooling and much more surface area for heat dissipation. This is a cooler that would remain happy with 450W+ TDPs.

The card has a full cover backplate with more pads for cooling PCB components, and one of the most spectacular RGB implementations we've seen, with full-length light bars along both sides of the card that really add a touch of class. Overall it looks and feels like an excellently engineered card.

The PCB is a 20-phase design with 90A stages. It's quite a step up from the reference card. You also get dual BIOS, which can be switched via Sapphire's Trixx software utility. It's powered by triple 8-pin power connectors for a total of up to 525W, and as we see in testing, it uses the extra juice.

The outputs consist of dual DP 2.1 and dual HDMI 2.1 ports, Sapphire opted to drop the USB Type-C connection.

The performance of the Sapphire Nitro+ 7900 XTX was eye opening. It consistently beat out the reference XTX, clocking nearly 200MHz higher than the reference card. It doesn't magically make it a 4090 competitor but it's enough to justify a price premium over the reference XTX. The core XTX traits apply, meaning it generally beats the RTX 4080 in traditional rendering, with RT performance matching the RTX 30 series.

If there's a negative it's that the extra performance comes at a cost to efficiency, with a large jump in power consumption. Though mostly spikes, the Sapphire was at times pulling as much as 80W more than the reference card, though it's important to remember things like the RGB contribute to that as well.

The Sapphire Pantheon cooler is the best AMD cooler we've come across to date. For such a power consuming GPU, the highest temperature I saw was a shockingly low 60 degrees. And the cooler didn't even need to work hard, staying effectively silent at all times. Well done Sapphire!

Sapphire has taken the Navi 31 GPU and unleashed it. It's faster, cooler, quieter and it looks better than the reference card. It's well worth the price premium Sapphire is asking for. Sure, the performance per watt isn't as impressive as we'd hoped for, but that's on AMD.

If you're after a graphics card to drive a high-resolution monitor at high FPS and don't care so much about ray tracing performance, then the Sapphire Nitro+ Radeon RX 7900 XTX Vapor-X is a very strong option. Who knows? AMD might be able to deliver some driver optimisation, elevating its chiplet architecture to higher levels. We really like this Sapphire, and apart from some hefty power consumption spikes, it's just a better 7900 XTX. Period.

The brawny Sapphire Nitro+ tosses aside the reference card's power limitations allowing it to reach its full potential.

Chris Szewczyk

★★★★☆

Conclusion

So, there we have it! AMD fights back with its highly anticipated RX 7900 series. The 7900 XTX isn't quite the all-conquering 4090 slaying competitor we hoped it would be, but it does what it needs to. As we see in the benchmarks, the XTX pulls ahead of the RTX 4080 in traditional rasterisation, but still can't match Nvidia's ray tracing or DLSS tech, though keep an eye on FSR 3.0 coming in 2023. AMD does have a value for money edge, a major advantage, though subject to change at any time.

AMD deserves a lot of credit for its bold decision to move to a chiplet architecture. Will upcoming drivers be able to extract more from the radically different architecture? It's certainly possible. AMD is in a good position to apply what it has learned, much like it did with Ryzen.

The 7900 XT is a bit of a curious case. It's priced too closely to the significantly better XTX. AMD needs to drop the XT's price which should make it a formidable RTX 4070 Ti competitor.

All in all, we conclude that the high-end GPU market status quo hasn't really changed. Nvidia has the fastest card in the 4090, as it did with the 3090/Ti, plus it has the excellent, though overpriced 4080. AMD's challengers offer better value and are very competitive in non ray traced games much like the 6800/6900 series was.

The first RDNA 3 cards are exciting, no doubt, but are the best examples yet to come? Mainstream gamers have a lot to look forward to. RX 7800/7700 class cards are set to battle Nvidia's offerings at price levels far more relevant to most gamers. We can't wait to see how those battles play out in the months ahead.

AMD RADEON RX 7900 XT & 7900 XTX BENCHMARK RESULTS

			AMD Radeon RX 7900 XTX	Sapphire Nitro+ Radeon RX 7900 XTX Vapor-X	AMD Radeon RX 7900 XT	MSI GeForce RTX 4080 Suprim X	Nvidia GeForce RTX 3080 Ti	Nvidia GeForce RTX 3080	AMD Radeon RX 6900 XT
Metro: Exodus Enhanced Edition	2560x1440 Extreme Preset	Min	55	59	47	59	44	39	38
		Avg	77	81	66	95	65	58	51
	3840x2160 Extreme Preset	Min	34	36	28	40	27	24	21
		Avg	43	45	36	54	38	34	27
F1 2021	2560x1440 Ultra High Preset	Min	140	147	118	175	127	114	103
		Avg	173	181	147	202	145	134	127
	3840x2160 Ultra High Preset	Min	80	85	68	99	73	65	55
		Avg	102	107	87	117	86	77	70
Total War: Warhammer III	2560x1440 Ultra Preset	Min	111	113	97	103	80	72	71
		Avg	147	149	127	136	108	96	93
	3840x2160 Ultra Preset	Min	58	57	49	56	44	33	35
		Avg	79	80	66	74	61	54	47
Cyberpunk 2077	2560x1440 RT Medium Preset	Min	24	26	24	62	41	38	27
		Avg	58	60	58	76	54	50	37
	3840x2160 RT Medium Preset	Min	16	17	16	31	20	17	12
		Avg	29	31	29	37	27	24	17
Far Cry 6	2560x1440 Ultra Preset	Min	120	120	121	129	104	116	107
		Avg	162	162	159	163	128	130	136
	3840x2160 Ultra Preset	Min	111	115	96	99	77	70	78
		Avg	122	127	106	108	85	79	85
Tiny Tina's Wonderlands	2560x1440 Badass Preset	Avg	158	166	137	170	125	114	131
	3840x2160 Badass Preset	Avg	85	89	73	90	71	64	69
Ghost Recon: Breakpoint	2560x1440 Ultimate Preset	Avg	169	171	156	146	112	108	127
	3840x2160 Ultimate Preset	Avg	107	111	93	96	78	72	75
3DMark	Time Spy Extreme		13,262	13,786	11,900	13,193	9,006	8,295	8,775
	Fire Strike Extreme		34,950	36,201	30,893	31,871	21,248	19,952	23,020
	RT Feature test		49.11	52.15	41.75	86.05	53.11	48.73	26.53
Power Consumption (Full system)	Watts		430	510	405	411	471	427	422

SOLID BUYS: M.2 SSDs

We'll never run out of the need for more storage. Whether you're upgrading or building a PC from scratch, an M.2 model is the way to go.

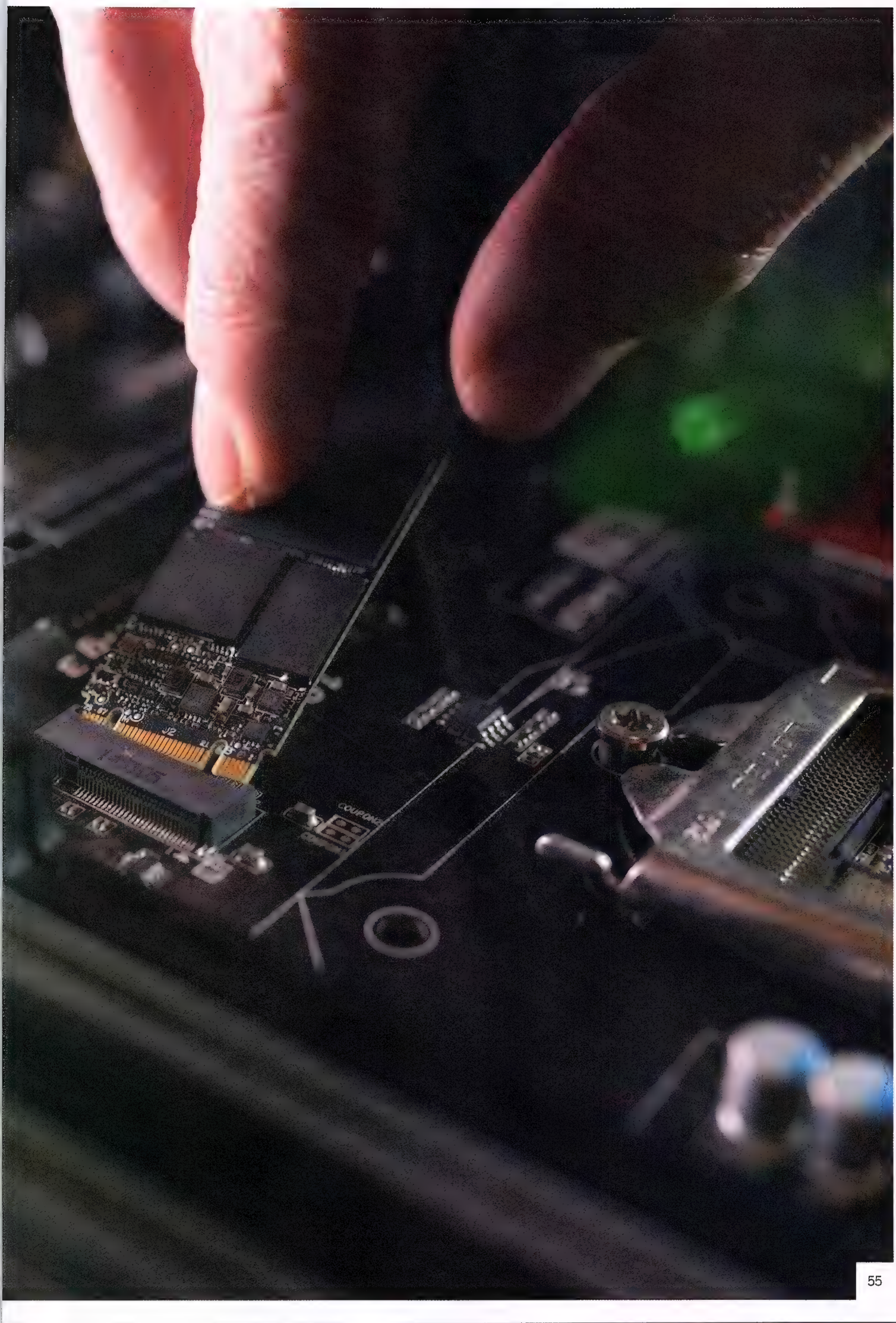
If there's one constant in computing, it's that we'll always need more storage. If there's a second, it's that the faster it is the better. Currently, the best storage option on both fronts is an M.2 SSD drive. If the move from mechanical drives to solid state was a step forward, then the move from 2.5in SSDs to M.2 has been a staggering leap in terms of performance and efficiency, and the technology continues to improve.

Mostly ditching the old SATA interface, which was designed for hard disks, M.2 drives primarily run using PCI Express, delivering speeds that seemed impossible a few years ago.

What's more, M.2 drives combine power and data in one connector, so there's less cable clutter in your PC and, as the drives plug directly into a socket on your motherboard, you can get away with a smaller case. That's great news for anyone who's fancied a mini PC but has been put off by the restrictive number of drive bays.

In this Labs test, we've got 14 of the latest M.2 drives, ranging from budget models up to the latest Gen 4 drives (also written as PCI-E 4.0 and PCIe 4.0) with the fastest speeds. What about SATA drives, you ask? Well, we've hit the limit of what these drives are capable of, and there are no new releases worth noting, so we've retested some of the drives from previous reviews..

David Ludlow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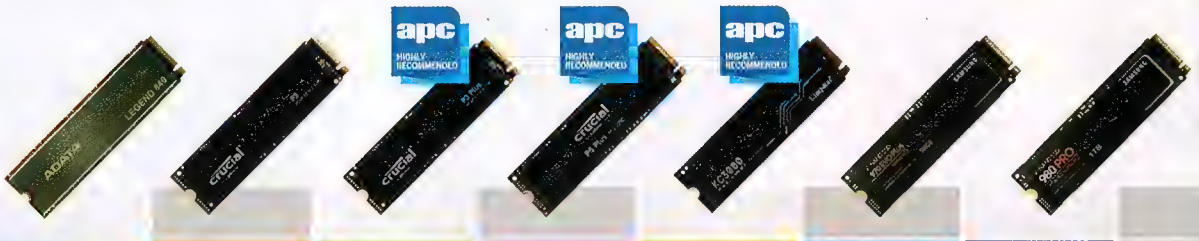
COUPONS



	Adata Legend 840	Crucial P3	Crucial P3 Plus	Crucial P5 Plus	Kingston KC3000	Samsung 970 Evo Plus	Samsung 980 Pro
Overall rating	★★★☆☆	★★★☆☆	★★★★☆	★★★★☆	★★★★☆	★★☆☆☆	★★★☆☆
INFORMATION							
Price as reviewed [1]	$140	$159	$159	$179	$329	$149	$219
Capacity tested	1TB	1TB	1TB	1TB	2TB	1TB	1TB
Other capacities	512GB	500GB, 2TB, 4TB	500GB, 2TB, 4TB	500GB, 2TB	1TB	250GB, 500GB, 2TB	250GB, 500GB, 2TB
Manufacturer's website	adata.com	crucial.com	crucial.com	crucial.com	kingston.com	samsung.com	samsung.com
Warranty	5yr	5yr	5yr	5yr	5yr	5yr	5yr
TECHNICAL FEATURES							
Type	NVMe	NVMe	NVMe	NVMe	NVMe	NVMe	NVMe
Data interface	PCI-E Gen4	PCI-E Gen3	PCI-E Gen4	PCI-E Gen4	PCI-E Gen4	PCI-E Gen3	PCI-E Gen4
Memory cell type	TLC	QLC	QLC	TLC	TLC	TLC	TLC
Formatted capacity	932GB	932GB	932GB	932GB	1.86GB	466GB	932GB
Claimed max read speed	5,000MB/sec	3,500MB/sec	5,000MB/sec	6,600MB/sec	7,000MB/sec	3,500MB/sec	7,000MB/sec
Claimed max write speed	4,500MB/sec	3,000MB/sec	3,600MB/sec	5,000MB/sec	7,000MB/sec	3,300MB/sec	5,000MB/sec
Endurance as reviewed	650TBW	220TBW	220TBW	600TBW	1,600TBW	300TBW	600TBW
Hardware encryption [2]	✓	✗	✗	✗	✗	✓	✓
PHYSICAL DESIGN							
Connectors	M.2 Key M	M.2 Key M	M.2 Key M	M.2 Key M	M.2 Key M	M.2 Key M	M.2 Key M
Dimensions (WD)	22 x 80mm	22 x 80mm	22 x 80mm	22 x 80mm	22 x 80mm	22 x 80mm	22 x 80mm
Drop/shock resistance	1500G/0.5ms	Not stated	Not stated	Not stated	Not stated	1500G/0.5ms	1500G/0.5ms
EXTRAS							
Bundled software	✗	SSD Management	SSD Management	SSD Management	✗	Samsung Magician	Samsung Magician
Supplied accessories	✗	✗	✗	✗	✗	✗	✗

1 Prices correct at time of going to press but are subject to change 2 All hardware encryption is 256-bit AES

	Seagate FireCuda 530	Seagate FireCuda Beskar Ingot	WD Black SN750	WD Black SN770	WD Black SN850	WD Blue SN570	WD Green SATA
					LABS WINNER		
Overall rating	★★★★☆	★★★☆☆	★★★★☆	★★★★★	★★★★★	★★★★☆	★★☆☆☆
Price as reviewed [1]	$215	$279	$119	$150	$229	$145	$36
Capacity tested	1TB	1TB	1TB	1TB	1TB	1TB	240GB
Other capacities	500GB, 1TB, 4TB	500GB	250GB, 500GB, 2TB, 4TB	250GB, 500GB, 2TB, 4TB	500GB, 2TB	250GB, 500GB, 2TB	480GB, 1TB, 2TB
Manufacturer's website	seagate.com	seagate.com	westerndigital.com	westerndigital.com	westerndigital.com	westerndigital.com	westerndigital.com
Warranty	5yr	5yr	5yr	5yr	5yr	5yr	3yr
Type	NVMe	NVMe	NVMe	NVMe	NVMe	NVMe	M.2
Data interface	PCI-E Gen4	PCI-E Gen4	PCI-E Gen3	PCI-E Gen4	PCI-E Gen4	PCI-E Gen3	SATA
Memory cell type	TLC	TLC	TLC	TLC	TLC	TLC	QLC
Formatted capacity	932GB	932GB	932GB	932GB	932GB	932GB	223GB
Claimed max read speed	7,300MB/sec	7,300MB/sec	3,100MB/sec	5,150MB/sec	7,000MB/sec	3,500MB/sec	2,400MB/sec
Claimed max write speed	6,000MB/sec	6,000MB/sec	2,600MB/sec	4,900MB/sec	4,100MB/sec	3,000MB/sec	900MB/sec
Endurance as reviewed	2,550TBW	1,275TBW	600TBW	600TBW	600TBW	600TBW	40TBW
Hardware encryption [2]	✗	✗	✗	✗	✗	✗	✗
Connectors	M.2 Key M	M.2 Key M	M.2 Key M	M.2 Key M	M.2 Key M	M.2 Key M	M.2 Key M
Dimensions (WD)	22 x 80mm	22 x 80mm	22 x 80mm	22 x 80mm	22 x 80mm	22 x 80mm	22 x 80mm
Drop/shock resistance	1500G/0.5ms	1500G/0.5ms	Not stated	Not stated	Not stated	Not stated	Not stated
Bundled software	SeaTools	SeaTools	SSD Dashboard	SSD Dashboard	SSD Dashboard	SSD Dashboard	SSD Dashboard
Supplied accessories	✗	✗	✗	✗	✗	✗	✗

How to choose the perfect M.2 SSD for you

Only fools rush into spending hundreds of pounds on storage. We set out 10 questions you must ask yourself before you spend a single cent.

1 Do I want an internal or external drive?

We've reviewed internal drives here, although with an external adapter you can use a USB drive instead. While USB 3.2 Gen 2 speeds are considerably faster than previous generations, they're not as quick as internal drives by a long shot. USB 3.2 Gen 2 2x1 runs at up to 10Gbits/sec, which works out at around 1,250MB/sec, a fraction of the maximum speeds of the latest SSDs. So why bother?

External drives are useful if you need to move data from one computer to another, or you want to take a secure backup of files, storing the drive in a different location or even a safe. External drives are also useful for devices that are hard to upgrade, such as laptops.

There's a big disadvantage: files on an external drive aren't accessible if the drive's not connected. That makes external drives largely unsuitable for storing apps or files you often need.

Right: External drives are better suited to laptops.

2 Should I get an SSD or a mechanical drive?

It's staggering to see mechanical hard disks still available. Their main advantage is that they're cheaper than their SSD equivalent, particularly in larger sizes. So, does overall size trump the speed and quality advantages of SSDs? In most cases, no.

Mechanical disks can be helpful if you have an older device that needs one, such as a NAS drive. If, for example, you're running an existing NAS and one hard disk fails, you'll need to replace it with the same. Otherwise, you should buy solid-state storage instead, be that an M.2 drive or even an older SATA drive.

3 What about SATA drives?

Talking about Serial ATA (SATA), are those drives still worth buying? The simple answer is no. SATA was designed in the time of mechanical hard disks, and tops out at speeds of around 600MB/sec – that's pretty slow in terms of today's storage.

The first SSDs used the SATA interface in a 2.5in format, because they had to utilise an existing storage connector. Today, M.2 drives are, for the most part, designed to be used with PCI Express, so there's very little point in buying an older SATA-based drive, mechanical or solid state.

Below: SATA drives such as Samsung's venerable 870 Evo are on the way out.

The only exception is if you've maxed out your M.2 slots and need to add additional storage, with only 2.5in drive bays free in your PC. A SATA SSD is then a better choice than a mechanical hard disk.

4 Are all M.2 drives the same?

Not quite. M.2 is the name of the slot, not the interface. M.2 slots can take SATA drives, running just as slowly as they would when connected via a SATA cable, but they can also run NVMe (Non-Volatile Memory express) drives. NVMe is a communications protocol designed for solid-state storage, built to deliver the fastest speeds.

NVMe uses PCI Express, of which the two current generations are PCI-E Gen3 and PCI-E Gen4 (also written PCI-E 4.0 and PCIe 4.0). The main difference between the two is in the speeds they provide. PCI Gen3 runs at 1,000MB/sec per lane, while PCI-E Gen4 doubles that to 2,000MB/sec. With most storage slots offering up to four lanes, that means that PCI-E Gen3 runs at up to 4,000MB/sec and PCI-E Gen4 up to 8,000MB/sec.

Support for PCI-E 4.0 depends on your processor and motherboard. At the minimum, you need a processor that supports PCI-E 4.0. It's then essential to have a motherboard that supports the technology.

You may find support is mixed, even on the same motherboard. For example, with a Ryzen 5 5000 series processor and B550 motherboard, one M.2 slot is controlled by the CPU and runs at up to PCI-E Gen4 speeds; the other slot is controlled by the chipset and runs at up to PCI-E Gen3 speeds.

Before you buy, check what slots you have and the speeds they run at, and what speeds your CPU supports. Unless you're planning an upgrade soon and will keep the storage, it's not worth paying extra for a PCI-E Gen4 SSD if it goes in a PCI-E Gen3 slot. While this will work, you'll be massively limiting the drive's speed.

5 Can I mix M.2 drives and SATA drives?

You can, although again, you'll need to do some research. In most cases, an M.2 slot will share a SATA connection with one port on the motherboard; the manual will tell you which. You can't have a SATA M.2 SSD and run a SATA drive from the shared port.

In most cases, you should avoid SATA, as explained above. But, if you are going to use SATA drives, in either regular or M.2 formats, just check the motherboard's manual first.

The restrictions don't apply if you're mixing NVMe and SATA drives, as there's no overlap or sharing.

6 How much space do I need?

This is the eternal question and one that's not easy to answer. For many people, a 1TB drive will provide more than enough storage for files and

applications, with larger backups and older files harvested off to the cloud, a NAS or external hard drive. If you play lots of games or edit many videos or photos, you may need 2TB of storage.

It's best to err on the side of caution when estimating how much storage you'll need. Data requirements keep growing, and there's nothing worse than buying a new drive and seeing an "out of storage" error message.

When estimating storage, look at how many storage slots you have on your motherboard, as you can always expand storage in the future. Splitting storage between a fast application drive and a secondary storage drive for files and games can be a good way to manage your storage needs.

In short, the best answer is to buy the biggest drive you can comfortably afford. That way, you'll give yourself the most amount of breathing room.

7 What speed drive should I buy?

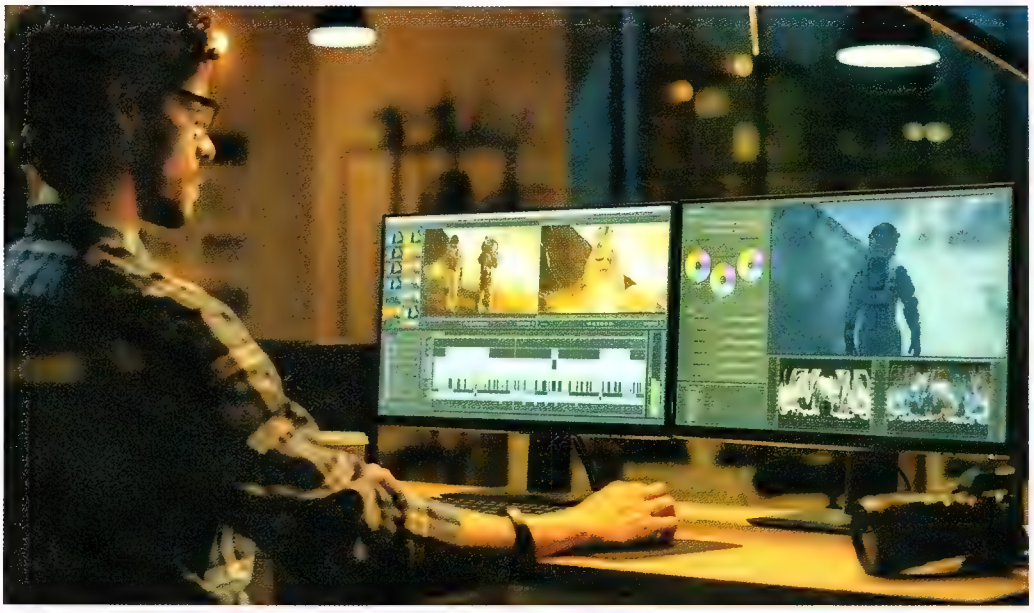
Again, this is a tricky question. If you look at the marketing bumph SSD manufacturers put out, they always quote the fastest speeds their drives are capable of, but they're not always in line with what you'll expect, as you can see from our performance graphs. It's actually rarely worth buying the latest and fastest drives, as you'll pay a premium and won't necessarily reap the rewards.

If you want a drive that's fast at loading Windows and apps, you need one that's fast with both sequential and random access files. If you've got a data storage drive for office files and photos, then neither factor is particularly important, and you probably won't see much day-to-day difference. In these cases, it may be better to forgo the latest technology and buy a larger drive overall.

8 Do I need to worry about drive longevity?

One of the scare factors about buying an SSD is that the memory chips inside them have a finite lifespan. Each time data is written, each cell becomes less reliable until it finally fails. Eventually the drive will fail, and it's game over.

Manufacturers estimate life using a write endurance figure. This figure is the total amount of data that can be written to the drive before it fails. It's measured in terabytes written (TBW). For most 1TB drives it's about 600TBW, scaling up and down with capacity.



Above: Creatives such as video editors should go large on storage space.

Once the TBW figure has been exceeded, your warranty is null and void, no matter when you bought the drive. A tool such as CrystalDiskInfo will tell you the current write figure, so you can keep a check on the drive, but many drives have software available from the manufacturer that tells you the same figure.

It's important not to get too hung up about reliability. After all, it's not as though mechanical disks didn't fail all the time! In most cases, SSDs will last for far longer than they're useful: by the time a drive has failed, you'll likely have upgraded it.

Nonetheless, you should take precautions and back up all your data. Once a drive has failed, reclaiming data is very difficult.

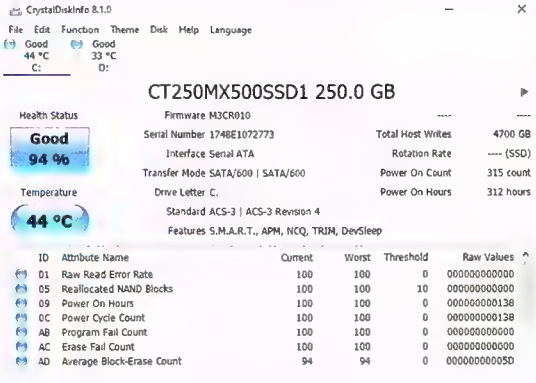
9 Should I use an SSD for a page file?

Run Windows 10 or 11 and you'll have a page file. Data is moved from RAM to the page file when physical memory is full. This ensures that Windows runs smoothly and doesn't crash, so you shouldn't disable the feature.

One common concern about the page file is that it can needlessly cause the SSD to write data and fail. However, that's not necessarily true. Windows 10 and 11 support the TRIM command, which simply marks blocks of data on an SSD as deleted, as opposed to erasing them. This means fewer write operations are required, which increases SSD life.

What's more, data is evenly spread across an SSD, rather than focusing on a set of memory locations. In short, Windows will work properly with an SSD and won't wear it out before its time. That said, it's worth speccing your PC to have the right amount of memory for you, as this will reduce the need for paging files and increase performance.

Below: Free tools can keep you informed of your drive's lifespan.


CrystalDiskInfo 8.1.0
File Edit Function Theme Disk Help Language
Good 44 °C C:
Good 33 °C D:
CT250MX500SSD1 250.0 GB
Health Status
Good
94 %
Temperature
44 °C
Firmware M3CR010
Serial Number 1748E1072773
Interface Serial ATA
Transfer Mode SATA/600 | SATA/600
Drive Letter C:
Standard ACS-3 | ACS-3 Revision 4
Features S.M.A.R.T., APM, NCQ, TRIM, DevSleep
Total Host Writes 4700 GB
Rotation Rate ---- (SSD)
Power On Count 315 count
Power On Hours 312 hours
ID Attribute Name Current Worst Threshold Raw Values
01 Raw Read Error Rate 100 100 0 000000000000
05 Reallocated NAND Blocks 100 100 10 000000000000
09 Power On Hours 100 100 0 000000000138
0C Power Cycle Count 100 100 0 000000000138
AB Program Fail Count 100 100 0 000000000000
AC Erase Fail Count 100 100 0 000000000000
AD Average Block-Erase Count 94 94 0 00000000005D

10 Cache or no cache?

SSD manufacturers have increased capacity by increasing the number of bits stored per memory cell. Triple-Level Cell (TLC) SSDs store three bits per memory cell, while Quad-Level Cell (QLC) drives store four bits. This is great in terms of capacity, but an increase in the number of bits increases the complexity of writing data.

That's why most SSDs have some form of cache. SDRAM cache has been used in the main, with fast memory sitting as a buffer between writes and the actual memory cells. This adds complexity and price to SSDs.

With capacities increasing, more and more SSDs are moving to Single-Level Cell (SLC) caching. This uses a portion of the SSD in Single-Level (SL) mode, writing one bit per cell. Once done, the SSD, in the background, moves the data to SLC or QLC cells. This technology can increase cache sizes and reduce the overall SSD price, but it relies on some empty SSD space. As the SSD is filled up, there's no room for the cache, and performance deteriorates.

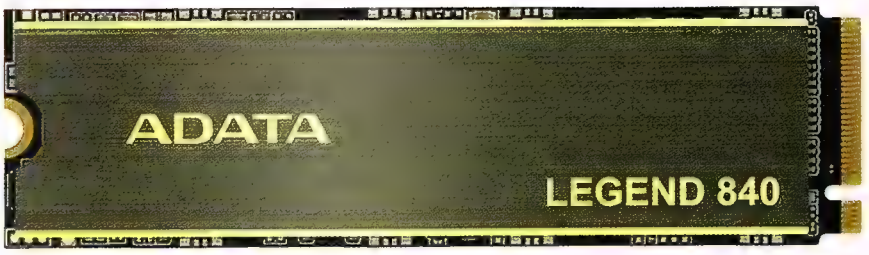
SLC caching drives also use Host Memory Buffer (HMB) technology, which uses system RAM for buffering and is supported by Windows 10 and 11. Ultimately, SLC caching can deliver the same or better performance than SDRAM, but buy a slightly larger drive than you think you may need.

ADATA LEGEND 840

A perfectly sound drive but it has tough competition this month, and it's also difficult to find.

★★★☆☆

1TB, $150 | adata.com



Designed for both PC and PS5 use, the Adata Legend 840 has some stiff competition. We've reviewed the 1TB model, although it's also available as a 512GB drive.

All drives ship with a heatsink as standard, which the company says keeps the drive 15 percent cooler. The competition at this price tends to ship with heatsinks, too, so it's not particularly an Adata advantage.

As is required for a drive that supports the PS5, the Adata Legend 840 has a PCI-E Gen4 interface. Here, the specs are just right for the PS5: a claimed read speed of 5,000MB/sec and a write speed of 4,500MB/sec. Both are good in their own right, but the issue here is mostly availability.

Not as widely available as its competitors, the cheapest we could find the Adata Legend 840 was $150 on Amazon. That's reasonable compared to than rivals, but all of the others have higher quoted read and write speeds.

> "There's nothing wrong with the Adata Legend 840 – it's quite fast overall – but it's just too expensive and hard to find."

Turning to the benchmarks, the Adata Legend 840 didn't perform as well as the main competition, either. In the PCMark 10 benchmarks, scores of 2,949 in the System Disk test and 3,699 in the Data Disk test are just below mid-table.

Similarly, moving to the AS SSD test the drive is mid-table for sequential performance: 4,423MB/sec in the read test and 4,649MB/sec in the write test. Things pick up in the random test, with the drive's controller and SLC cache helping it achieve 2,474MB/sec read speeds and 2,487MB/sec write speeds. These are good results in their own right, but the competition is faster.

Endurance is good, with the drive rated at 650TBW, which is slightly above the industry average. However, the improvement isn't so good that this drive's higher price can be forgiven. In fact, the Seagate FireCuda 530 offers almost double the endurance, making it a better drive for gaming.

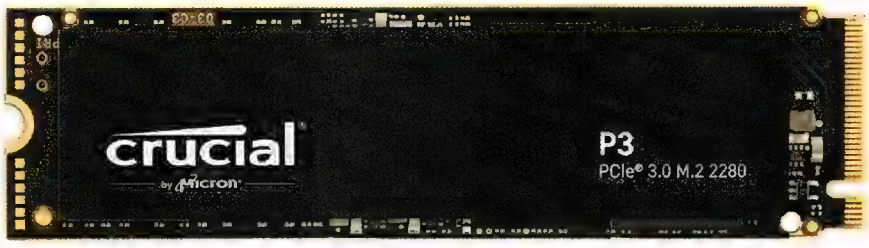
There's nothing wrong with the Adata Legend 840 – it's quite fast overall – but it's just too expensive and a bit hard to find. The WD Black SN850 or Seagate FireCuda 530 are better choices.

CRUCIAL P3

At current prices the WD Blue SN570 makes a better choice, but find the P3 for less and that could change.

★★★☆☆

1TB, $159 | crucial.com



One of the cheapest SSDs you can buy, and from a brand that has a well established Australian presence. Thanks to its QLC storage, it's also available in 500GB, 2TB and 4TB formats. As a cheaper M.2 SSD, this drive uses the slightly older PCI-E Gen3 interface.

As with other budget drives, there's no SDRAM cache on this model, with the drive instead using SLC caching and a Host Memory Buffer (HMB), where system memory acts as the buffer. As we've seen with other drives to use similar techniques, this no longer dramatically impacts performance.

In fact, the Crucial P3 did rather well in all of our benchmarks. In the PCMark 10 System Disk test, the Crucial drive scored 3,210, and it also scored 4,825 in the Data Disk test. Both benchmarks are based on regular real-world usage, so high scores here suggest that the drive will be efficient in regular use.

> "While 220TBW is fine for regular PC use, the P3 will fail sooner than its rivals."

When it comes to more demanding use, such as games or large file copies, the AS SSD benchmarks show what a drive is made of. Here, the P3 drops further down the table, with sequential read speeds of 3,217MB/sec and read speeds of 2,933MB/sec.

Similarly, the random file test delivered read speeds of 1,942MB/sec and write speeds of 2,234MB/sec. Both results are above the similar WD Blue SN570, but there are some other important differences between the two drives. While the WD Blue SN570 has an endurance of 600TBW, the Crucial P3 has an endurance of just 220TBW, almost a third less.

While 220TBW is fine for regular PC use, the P3 will fail sooner than its rivals. If you have more demanding uses for your PC, such as video editing or playing games, then we'd suggest that you look for a drive with more longevity, even if you have to sacrifice a bit of performance along the way.

The Crucial P3 is a decent performer and well priced, but the competition is tough. For slightly less money, the WD Blue SN570 offers similar performance, bar in the random file test, and better endurance. Those looking to build a budget PC would be better off with that drive.

CRUCIAL P3 PLUS

A 1TB Gen4 drive for a good price, but it misses out on award thanks to the cheaper WD Black SN770.

★★★★☆

1TB, $159 | crucial.com

Although it has a similar name to the Crucial P3, the P3 Plus is a slightly different beast. Here, the drive has been upgraded to a PCI-E Gen4 interface, up from the Gen 3 interface on the standard P3.

Claimed read and write figures have been improved to 5,000MB/sec and 3,000MB/sec respectively. That means the benchmark results are better, although not necessarily by as much as you might expect.

In the AS SSD sequential test, the P3 Plus managed read speeds of 4,267MB/sec and write speeds of 3,344MB/sec, which puts it well above the P3. Things are closer in the Random test, with the P3 Plus scoring 2,003MB/sec read speeds and 2,588MB/sec write speeds: only fractionally ahead of the P3.

Turn to the PCMark 10 benchmarks and it's a similar story: the P3 Plus scored 3,352 in the Data Disk test and a huge 5,238 in the Data Disk test, which is only just behind the WD Black SN770.

> "As with the P3, the drive is also available in 500GB, 2TB and 4TB sizes, alongside the 1TB drive we reviewed here."

As with the P3 and the SN770, the P3 Plus doesn't have any SDRAM cache, relying on system memory and an SLC cache. For normal tasks, as the PCMark 10 results show, this is a fast SSD.

The downside of the QLC storage used is that endurance is lower than the industry average: here, the 1TB drive has an endurance figure of 220TBW, almost a third of the average of 600TBW. Is that important? Well, if you're going to use the drive for demanding tasks, such as games or video editing, then possibly; for regular use, this SSD will last the distance.

As with the P3, the drive is also available in 500GB, 2TB and 4TB sizes, alongside the 1TB drive we reviewed here.

Competition at this price is very tough, with the WD Black SN770 not only cheaper for the same capacity, but outdoing the P3 Plus in the benchmarks, as well as offering better endurance. That makes the WD Black SN770 the better choice for most people.

CRUCIAL P5 PLUS

Just like the Crucial P3 Plus, this speedy drive is ousted from the top spot due to an even better WD rival.

★★★★☆

1TB, $179 | crucial.com

At the top of Crucial's SSD lineup is the P5 Plus. This is a thoroughly modern drive, with some of the fastest throughputs available. We've reviewed the 1TB drive, although 500GB and 2TB models are also available.

As you might expect from a modern SSD, this M.2 drive uses the PCI-E Gen4 interface, which means that quoted throughputs are 6,600MB/sec read speed and 5000MB/sec write speeds. Both are fast enough that the drive can be used in the PS5, as well as in a PC.

> "Quoted throughputs are 6,600MB/sec read speed and 5000MB/sec write speeds. Both are fast enough that the drive can be used in the PS5, as well as in a PC."

As well as these quoted speeds being faster than those for the P3 Plus (another Gen4 drive), the benchmarks show that the P5 Plus is a considerable way ahead for sequential transfers. Scoring 5,492MB/sec write speeds and 4,516MB/sec read speeds, the P5 Plus sits firmly in the premium category and is a genuinely fast drive, able to cope with more demanding uses.

Move to the random file test, and the P5 Plus isn't quite as good. It's faster than its siblings, but drops down the table compared to the competition: 2,222MB/sec write speeds and 2,707MB/sec read speeds.

Moving to the PCMark 10 benchmarks, which simulate regular use, the P5 Plus scored highly in the Data Disk test (3,506) but wasn't quite as impressive as its stablemates in the Data Disk test (4,815).

This SSD uses TLC memory and has an SLC cache (the size of which depends on the total size of the drive). Using TLC, rather than QLC as the cheaper Crucial drives do, means that endurance is improved. At 600TBW for the 1TB model, the Crucial P5 Plus has average industry endurance.

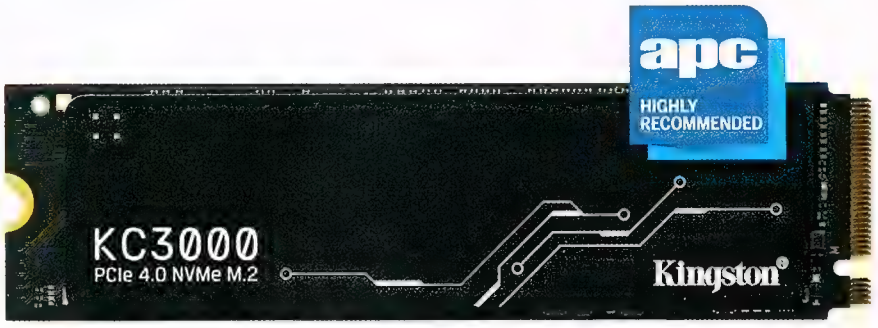
Again, the only thing that gets in the way of the Crucial P5 Plus is the price. While it's not an expensive drive, the WD Black SN850 only costs a little more, yet is faster in all tests, while the slightly more expensive FireCuda 530 is faster in AS SSD and has even better endurance figures. Based on this, either drive is a better buy for most people.

KINGSTON KC3000

This Gen4 SSD was worth waiting for: it offers superb value for money if you don't need cutting-edge speeds.

★★★★☆

2TB, $329 | kingston.com



One of the last companies to offer a PCI-E Gen4 M.2 SSD, Kingston certainly hasn't messed about with the final product, delivering a fast and enduring piece of storage. We've reviewed the 2TB model (technically 2,048GB), although there are also 512GB, 1,024GB and 4,096GB models in the lineup, too.

This particular SSD offers headline speeds of up to 7,000MB/sec read and write. Not only does this make it one of the fastest drives on paper, it puts it beyond the minimum specifications required for use in the PS5.

Similar to the Seagate FireCuda 530, the Kingston KC3000 doesn't use DRAM as a cache but instead uses part of the drive in SLC mode. This reduces hardware costs and, as the KC3000 can use up to one-third of the storage space for the cache, means there's more for Windows to play with.

Well, there is up to the point that the drive is full, as using part of the drive in SLC mode only works while there's spare space; as the drive fills up, SLC has to be converted back to TLC.

Still, this approach is a clever one, and the SSD reaps the benefits in our benchmarks. Managing 3,278 in the PCMark 10 System Disk benchmark and 4,607 in the Data Disk benchmark, the Kingston KC3000 is one of the fastest drives available.

> "Endurance is among the best of any drive here: for the 2TB drive on review, endurance is 1,600TBW, and 800TBW for the 1TB drive."

Similarly, it does well in the AS SSD benchmarks. In the sequential test, read speeds of 5,736MB/sec and write speeds of 3,949MB/sec are only just behind the WD Black and Seagate FireCuda drives. Performance falls a little further behind in the random tests, with read speeds of 2,422MB/sec and write speeds of 2,922MB/sec. This is still a blazingly fast SSD, able to cope with any job.

Endurance is among the best of any drive here: for the 2TB drive on review, endurance is 1,600TBW, and 800TBW for the 1TB drive. Only the Seagate FireCuda 530 offers more endurance at the same capacities.

Price is also a big bonus for the Kingston KC3000: it's cheaper per gigabyte than any of its high-end competition. Overall, the WD Black SN850 or FireCuda 530 offer slightly better performance, but if you want to save a bit of cash, this is a fast and reliable SSD.

SSD sizes explained

How to decode the strings of numbers used to describe M.2 drives

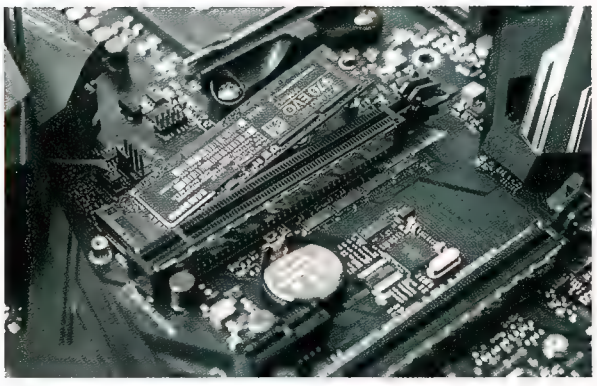
All of the M.2 drives that we've included are 2280 drives, which are the most common type you'll find, but there are a host of other physical drive sizes out there. So what are the differences? Quite simply, the figures explain the key dimensions of the drive: the first two numbers are the width of the drive in millimetres, and the second number is the length in millimetres.

So, our 2280 drives are 22mm wide and 80mm long. This is the most common size, allowing the most room for memory chips, so capacities tend to be higher at a lower cost. It's not the only type of SSD, though.

The other common formats are 2260 (60mm long) and 2242 (42mm long), with the even smaller 2230 (30mm long) size starting to become popular. Typically, the smaller formats are used in laptops, where there's not always space for a "full-size" SSD.

Cutting down the amount of space on the physical board means that there's less space for memory chips, so smaller-sized SSDs tend to have lower capacities. That said, increasing chip density is one of the reasons for the increasing popularity of 2230 drives. You'll most commonly see them in ultraportable laptops, but we have seen M.2 2230 slots appear in bigger laptops as a way to expand on the supplied storage.

Part of the M.2 configuration is the physical connector. All of the drives we've reviewed use the Key M type connector, which will only work in slots with the female Key M connector. There are different Key types, although M is the most popular.



All the SSDs we've reviewed this month have the same 22 x 80mm dimensions.

Typically, most laptops will only take an SSD of one size, so if you're upgrading, you have to swap like for like, reducing your choice. PCs are different, as motherboards have a movable SSD standoff that can go in different positions.

The standoff can be unscrewed and moved to a new position. The SSD then sits on top of this and is held in place by a retaining screw. While you'll most likely end up with a 2280 SSD, the PC's versatility means that you can install a laptop-sized SSD if needed. That can be handy if you have an old laptop that you're cannibalising for parts, or you simply want to read a laptop SSD on your computer.

SAMSUNG 970 EVO PLUS

Quite simply too expensive for a Gen3 drive, meaning there are few reasons to choose it over rivals.

★★☆☆☆

1TB, $149 | samsung.com

Once the darling of PC builders everywhere, offering fantastic speeds at lower prices than the Pro range, the 970 Evo was the budget drive to buy. Unfortunately, it's now relatively expensive, particularly for a PCI-E Gen3 drive.

Here, we've tested the 1TB version, although it's also available in 250GB, 500GB and 2TB versions. As with other SSDs, the 250GB version is a little too small to be of use, so we'd avoid that drive and go with at least the 500GB model, if not larger. All versions have a DRAM cache, with the size dependent on the drive.

Not only is the 970 Evo Plus expensive for a Gen3 drive, it's more expensive than PCI-E Gen4 drives, including the WD Black SN850, WD Black SN770 and the fastest sequential drives we've reviewed, the Seagate FireCuda models.

> "The 970 Evo Plus is slower than the WD Blue SN570, which is a lot cheaper, and the Crucial P3 and Crucial P3 Plus drives."

That makes the 970 Evo Plus a hard sell. In our benchmarks, the drive was towards the bottom of the table. In PCMark 10, the drive scored 1,535 in the System Disk test and 1,955 in the Data Disk test.

Results were similar with the AS SSD tests. In our sequential benchmark, the 970 Evo Plus managed 3,036MB/sec read speeds and 2,651MB/sec write speeds; in the random file tests, the drive achieved 1,934MB/sec read speeds and 2,380MB/sec write speeds.

For the most part, bar the random test, the 970 Evo Plus is slower than the WD Blue SN570, which is a lot cheaper, and the Crucial P3 and Crucial P3 Plus drives.

Everything else about this drive is pretty much standard. The 1TB version is rated to last for 600TBW, which is the industry average. It means that the 970 Evo Plus will last for longer than you'll realistically need the drive.

A lot could be forgiven if this drive were a lot cheaper. Indeed, over the years, we'd expect this drive to fall in price. Rather, the opposite has happened and prices have remained high. Paying premium prices for a drive like this just doesn't make sense. If you've got a PCI-E Gen4 system, there are better choices; if you're running PCI-E Gen3, there are cheaper and faster alternatives.

PCI-E Gen3 vs PCI-E Gen4

How much difference does a generation make?

The best M.2 SSDs use the NVMe interface, which runs over PCI Express. The key difference between the drives we've reviewed is in the version of PCI Express that they use, with PCI-E Gen3 and PCI-E Gen4 drives on test. You may see the latter described as PCI-E 4.0, PCIe 4.0 or PCI-Express 4.0 as well.

The main difference between Gen3 and Gen4 is the speed of the lanes. With PCI-E Gen3, the speed per lane is 1,000MB/sec, while PCI-E Gen4 doubles this to 2,000MB/sec. The SSDs that we've reviewed can run up to four lanes, for a total bandwidth of 4,000MB/sec on PCI-E Gen3 and 8,000MB/sec on PCI-E Gen4. As ever, bandwidth doesn't always translate into real-world speed.

It's not only the SSD that needs to run at Gen4 speeds, but the motherboard as well. Here, your motherboard manual (or indeed the manufacturer's website) is your friend, as it will make it clear which generation is supported. And note that not all M.2 slots on a board are born equal, as it's quite common for one M.2 SSD to be Gen4 and the secondary slot to be Gen 3.

PCI-E Gen3 SSDs will work in Gen4 slots, but they won't run any faster; PCI-E Gen4 SSDs will work in Gen3 slots, although they will run slower. That means that it's not particularly worth buying a Gen4 SSD if your computer only has Gen3 slots. The only time we'd recommend this is if you're going to upgrade your computer soon and want to use the storage you've bought.

AS SSD SEQUENTIAL READ/WRITE (MB/SEC)

	READ	WRITE
WD Black SN850 over PCI-E 4.0	6,005	5,429
WD Black SN850 over PCI-E 3.0	2,935	2,126

So, how much difference does it make? Above we've included the benchmarks for the WD Black SN850, running in both PCI-E Gen3 and PCI-E Gen4 slots. As you can see, it makes a big difference for sequential read and write speeds, with Gen 4 offering double the performance; the difference is less pronounced when it comes to random file access.

You need a CPU that supports PCI-E Gen4 to use the fastest SSDs.

SAMSUNG 980 PRO

A fast Gen4 drive, but with speedy and cheaper rivals there's no justification for the premium being charged.

★★★☆☆

1TB, $219 | samsung.com

It was one of the first PCI-E Gen4 drives and the fastest drive that you could buy for a while, but the Samsung 980 Pro no longer has that title. A shame, really, given that it's still on sale for such a premium price. In fact, it's the most expensive drive per gigabyte here, apart from the special edition Seagate FireCuda Beskar Ingot.

We've reviewed the 1TB version, although it's also available in 250GB (too small to be of much use), 500GB and 2GB versions.

When it was first launched, the Samsung 980 Pro was one of the most powerful drives available. With its 1GB SDRAM cache and high quoted throughputs, this drive can't be called slow. Indeed, it can still put a shift in, as shown in our benchmarks.

> "When it was first launched, the Samsung 980 Pro was one of the most powerful drives available."

Managing 4,981MB/sec in the sequential read test and 3,940MB/sec in the sequential write test, the 980 Pro manages to outdo the brand-new WD Black SN770 drive. That's also the case in the random test, where scores of 2,747MB/sec read and 2,944MB/sec write speeds put the 980 Pro fourth in the table. Given that this drive is a few years old now, that's good going.

Turn to PC Mark 10's real-world benchmarks, and the 980 Pro starts to lose its composure. Its System Disk score of 2,769 and Data Disk score of 3,630 puts this drive at a distinct disadvantage compared to its newer competition.

There's full drive encryption built in, and the Samsung Magician software can be used to benchmark the drive. Neither is enough to make this drive worth choosing over rivals.

Rated at 600TBW for endurance, the 980 Pro is exactly what we'd expect from a drive: this figure shows that the SSD should more than outlast any PC in which you install it.

The simple fact, however, is that times have moved on, and the Samsung 980 Pro is still priced as if it were the fastest drive available. That's not the case: there are much faster PCI-E Gen4 drives if you want the best performance, and much better-value drives if you want more storage for less cash.

SEAGATE FIRECUDA 530

A great choice for the most demanding users, but if you don't need blazing speeds then you can save some cash.

★★★★☆

1TB, $215 | seagate.com

Seagate's top-of-the-range offering, the FireCuda 530, is built to be a thoroughly modern drive, delivering the fastest read and write speeds via its PCI-E Gen4 interface. We've reviewed the 2TB drive here, although it's also available in 500GB, 1TB and 4TB sizes.

Before we get into the performance details, it's first worth noting that this drive has a huge endurance figure of 2,550TBW for the 2TB drive, while the 1TB drive is 1,275TBW. That's more than double the industry average of 600TBW for a 1TB drive.

While a figure of 600TBW means that a drive will last for as long as you're likely to need it, having more endurance is particularly important if you've got demanding needs, such as for games or video editing, where the number of writes will be higher on average.

> "For everyday use, the FireCuda 530 is also good, but it drops down the league table compared to the WD Black SN850."

This drive has no SDRAM, but uses an SLC cache instead. Performance is impressive, and read/write speeds are exceptional with this drive. It scored 6,122MB/sec in the sequential read test and 5,765MB/sec in the write test. That's the fastest result that we've seen from an SSD. It's the same with the results in the random file test: 3,005MB/sec in the read test and 2,831MB/sec in the write test.

These speeds are phenomenal and show the FireCuda 530 is a high-end drive that can really cope with the most demanding needs. What's more, that's not just in a PC, as this drive is fully compatible with the PS5.

For everyday use, the FireCuda 530 is also good, but it drops down the league table compared to the WD Black SN850. The FireCuda 530 scored 3,100 in the PCMark 10 System Disk test and 4,478 in the Data Disk test. Both are good, but there are faster drives in this test that boost performance in normal use.

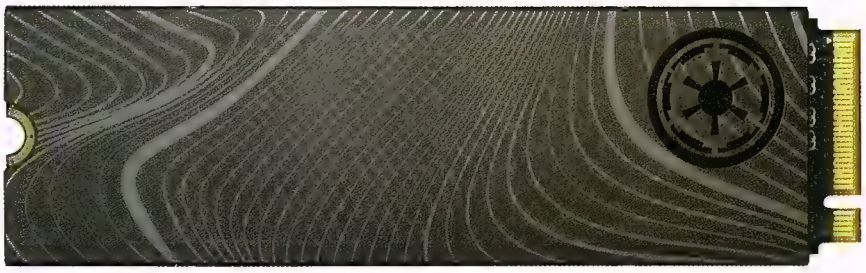
Those results shouldn't take too much away from the FireCuda 530. Overall, the WD Black SN850 offers a slightly better balance of performance and price for regular use, but if you have more demanding needs, want a faster overall drive for large transfers and need the extra longevity, the FireCuda 530 is an excellent choice.

SEAGATE FIRECUDA BESKAR INGOT

A special edition for fans of The Mandalorian, and you pay a premium, but there's no denying the quality.

★★★☆☆

1TB, $279 | seagate.com



A special edition drive to tie in with *The Mandalorian*, the FireCuda Beskar Ingot is designed to look like the currency in which the titular character is paid. Seagate has done a great job of it, taking a FireCuda 530 and encasing it in a new heatsink.

As a result, the drive is much thicker than a normal M.2 SSD, at 80mm tall. Then there's the case of whether or not the drive will be seen. Most M.2 slots on a regular PC are tucked out of the way, or even hidden from view because of the CPU cooler. Given that this drive is more expensive than the regular FireCuda 530, you'll want to install it in a case with a clear window and an equally clear view of the drive.

"In the AS SSD benchmark, scores of 6,179MB/sec reads and 5,879MB/sec writes in the sequential test put this drive at the top of the table"

As the base drive is a FireCuda 530, you get all the benefits of that drive. We tested the 1TB version, but there's also a 500GB version available; larger 2TB and 4TB drives are limited to the regular FireCuda drive.

One of the standout features is the endurance of this drive, rated at 1,275TBW for the 1TB version. That's double the standard 600TBW and shows that this drive is built for more demanding use, such as a gaming PC.

Thanks to the modern controller and PCI-E Gen4 interface, the Seagate FireCuda Beskar Ingot is also fast. In the AS SSD benchmark, scores of 6,179MB/sec reads and 5,879MB/sec writes in the sequential test put this drive at the top of the table. Similarly, the 4K random test shows that this drive is the fastest you can get: 2,842MB/sec read and 2,865MB/sec write. These tests show expected performance in more enduring tasks.

For regular use, the PCMark 10 benchmarks show normal performance. Here, the FireCuda Beskar Ingot is a little slower (though not slow): 3,135 in the System Disk test and 4,510 in the Data Disk test.

Technically, the Seagate FireCuda Beskar Ingot is a great drive and exceptionally fast. It's also lovely to look at. Given its higher price, the regular FireCuda 530 is a better buy if you want the best performance, but if you are tempted by this design then hurry as it is now in short supply.

WD BLACK SN750

This positively ancient Gen3 drive still holds its own, especially if your PC doesn't include a Gen4 slot.

★★★★☆

1TB, $119 | westerndigital.com

It's incredible that the WD Black SN750 is still around. Launching back in 2019, this drive has been around for a long time in technology terms. The reason that it's still available is that this was a flagship drive back in the day. Today, based on the PCI-E Gen3 standard, it's slower than the competition, yet for an older computer or those looking for a budget drive, it's still a good buy.

At its time of launch, the drive's specifications indicated that it was pushing the limits of what the PCI-E 3.0 interface could achieve. Our results show that this is still true. In our sequential benchmark, the drive managed 3,071MB/sec in the read test and 1,828MB/sec in the write test.

"If you have a Gen 4.0 slot, then the WD Black SN770 is streets ahead of this drive, but not that much more expensive; if you have an older PC in need of an upgrade, however, this is still a solid choice."

Moving to the random test, the drive managed 1,255MB/sec in the read test and 2,117MB/sec in the write test. Both benchmarks place the drive towards the bottom of the benchmarking tables, but the SN770 still beats some newer drives in the mix. Faster drives in this test tend to use the newer PCI-E Gen4 interface, which offers double the bandwidth; however, these drives need a Gen4 M.2 slot to get these speeds.

In the PCMark 10 benchmarks, the SN750 is towards the bottom of the scoreboard: 1,122 in the System Disk test and 1,423 in the Data Disk test.

That may not sound particularly impressive, but if you have a PC with a PCI-E Gen3 slot, then the WD Black SN750 is still quick. It's also good value, although we would recommend buying the 1TB version, as it's not much more expensive than the 500GB option, while the 250GB is too small to be useful. Endurance is as we'd expect for a modern SSD at 600TBW.

Whether this drive is for you depends on what you want to use it for. If you have a Gen 4.0 slot, then the WD Black SN770 is streets ahead of this drive, but not that much more expensive; if you have an older PC in need of an upgrade, however, this is still a solid choice. The only caveat is that if you're planning a PC upgrade soon and want to keep the storage, buy the SN770 instead.

WD BLACK SN770

A blazingly fast drive in day-to-day use coupled with a great price make this a superb-value choice.

★★★★★

1TB, $150 | westerndigital.com

A new drive, the Black SN770 is the spiritual successor to the ageing WD Black SN750. While they have similar names, the SN770 has more in common with the SN850 than the older drive.

For starters, this drive has a PCI-E Gen4 interface, rather than the Gen3 of the SN750. And it costs only a little more than its predecessor.

Changing the interface is one thing, but it's the increase in performance that's particularly impressive. When running the PCMark 10 benchmarks, we were a little surprised to see that the SN770 topped the table. In fact, we were so surprised that we reran the tests, checked them again, and then reran the benchmarks on the SN850.

> "If you're building a mid-range or lower-spec PC but don't want to compromise on storage performance, the WD Black SN770 is quite a stunning buy."

Our eyes were not deceiving us: the SN770 was faster in the PCMark 10 benchmarks, scoring a huge 3,850 in the System Disk test and 5,879 in Data Disk. That's impressive for such a well-priced drive, and shows the power of the SLC cache.

Things slow down when it comes to sequential and random read and write speeds, as this drive uses a DRAM-less design. Sequential write speeds of 4,596MB/sec and read speeds of 4,459MB/sec aren't slow, but they aren't exceptional either. Likewise, the random read speeds of 2,342MB/sec and write speeds of 2,743MB/sec are mid-table.

Sequential speeds, both in our tests and the official specs, are below that required for the PS5, so this drive is no good as an upgrade there.

Storage capacities include 250GB, 500GB, 1TB and 2TB, all shipping without a heatsink, which isn't required for a drive of this speed. We reviewed the 1TB model, but would say the 250GB model isn't a good buy, both in terms of price and capacity.

Endurance is rated at 600TBW for the 1TB model, which is exactly what we'd expect from a modern drive. If you're building a mid-range or lower-spec PC but don't want to compromise on storage performance, the WD Black SN770 is quite a stunning buy, provided your computer supports PCI-E Gen4. It's only if you need storage that can handle more demanding tasks, such as large file copies or games, when the WD Black SN850 or Seagate FireCuda 530 become better choices.

LABS WINNER

WD BLACK SN850

A staggeringly fast PCI-E Gen4 drive that's the obvious choice for the most demanding users.

★★★★★

1TB, $229 | westerndigital.com

It's been around for quite a while now, but the WD Black SN850 runs at the current PCI-E Gen4 speeds, so it can still put in a shift. And it's better value now than it was at launch thanks to a price drop or two.

We've reviewed the 1TB model, although there are 500GB and 2TB versions available. All are available with and without heatsinks, with WD recommending heatsinks for use in PCs and the PS5 .

The last time we reviewed this drive, the heatsink version was hugely more expensive. Fortunately, times have changed, and the heatsink version is now excellent value: $229 for such a fast 1TB drive really is excellent value.

> "On balance, the SN850 is still the overall best drive available, across all the benchmarks, with the WD SN770 falling behind in sequential and random tests."

As the basis of a new PC, there's still a lot going for this drive. In our benchmarks, we measured the drive at 6,005MB/sec read and 5,429MB/sec write speeds. Only the Seagate FireCuda drives do better in this test.

It's the same story in our random tests. At 2,772MB/sec read speeds and 2,580MB/sec writes, the WD Black SN850 is only marginally outclassed by the two Seagate drives in this test.

In the PCMark 10 test, the WD Black SN850 is also a capable performer. Scoring 3,508 in the System Disk benchmark and 5,048 in the Data Disk benchmark, this drive pretty much tops the table. It's outclassed only by the newer WD Black SN770.

On balance, the SN850 is still the overall best drive available, across all the benchmarks, with the WD SN770 falling behind in sequential and random tests. The SN770 also falls short of the requirements for PS5 use, whereas the SN850 is compatible.

Endurance for this drive is rated at 600TBW for the 1TB edition, which is just about what we'd expect. The simple fact is that this drive will more than outlast your needs when used in a regular computer.

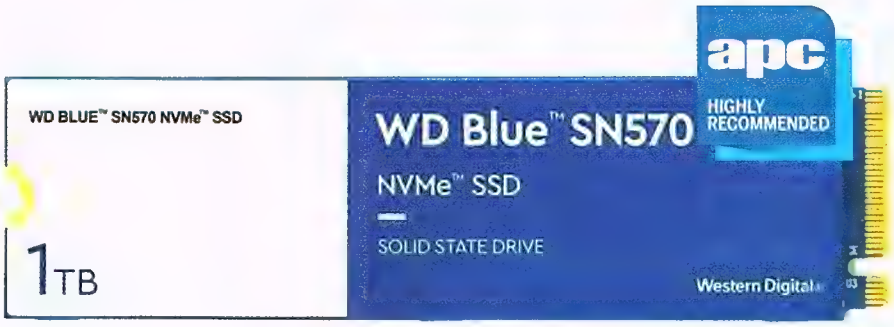
While the WD Black SN770 is a great new entry, if you want the overall best that the PCI-E Gen 4.0 interface can offer, with the fastest recorded transfer rates, then this is the model to buy.

WD BLUE SN570

Looking for a great-value Gen3 drive? Once again WD gets the balance of price and performance just right.

★★★★☆

1TB, $145 | westerndigital.com



The previous generation of this drive, the WD Blue SN550, was something of a bargain: pretty fast, but great value. It's a trick the WD Blue SN570 again manages to pull off, mostly outclassing its older, higher-rated competition.

We tested the 1TB model, although this drive is also available in 250GB, 500GB and 2TB models. None has – nor requires – a heatsink.

As with its predecessor, this drive is a PCI-E Gen3 model, which limits how fast it can be. That's not necessarily a problem, as its rated read and write speeds are below even what PCI-E Gen3 can offer.

Like many cheaper SSDs, the Blue SN570 doesn't have a DRAM cache, using SLC caching and HMB instead (see p83). In our sequential benchmarks, the drive did all right, managing 3,215MB/sec in the read test and 2,357MB/sec in the write test. That actually puts it above the older WD Black SN750, which launched as a premium drive a few years ago.

> "It's excellent value across its capacity range, and its performance results are encouraging where it counts."

However, the Black SN750 showed its mettle in the random tests, whereas the Blue SN570 fell behind: it returned 881MB/sec reads and 1,492MB/sec writes. That puts it more towards the bottom of the table.

In the PCMark 10 tests, the WD Blue SN570 managed a System Disk score of 2,315 and a Data Disk score of 2,953. That's above the Samsung 970 Evo, a favoured budget drive of old, and even the SN770.

Endurance is rated at the industry average of 600TBW for the 1TB drive. In other words, you don't need to worry about this drive failing before it's obsolete.

While the older SN750 does better in the random access file test, that's the only place that it outclasses the newer SN570. For most PC users looking to build a budget computer, or looking to upgrade an older PC with PCI Gen 3.0 slots, the WD Blue SN570 is a great choice.

It's excellent value across its capacity range, and its performance results are encouraging where it counts. WD has got the balance right with this drive, and it's a great option if your budget won't stretch to or your PC won't take a faster drive.

WD GREEN SATA

Cheap, but the performance penalty of SATA rather than PCI Express means we can't recommend it.

★★☆☆☆

240GB, $36 | westerndigital.com

At just $36 for a 240GB drive and $40 for a 480GB drive, the WD Green is certainly cheap for an SSD. Similarly cheap 1TB and 2TB drives can be picked up. There's a reason for this: it doesn't use PCI-E at all but the older SATA interface.

(Note: this drive isn't to be confused with the WD Green SN350. Although both models share the "Green" name, the SN350 is an NVMe drive, rather than a SATA one.)

That firmly puts this drive at the bottom of the table for every single test we ran, as the SATA interface is so limited and slow. In our sequential test, scores of 524MB/sec read and 442MB/sec write put the drive way down at the bottom.

> "If you have a Gen 4.0 slot, then the WD Black SN770 is streets ahead of this drive, but not that much more expensive; if you have an older PC in need of an upgrade, however, this is still a solid choice."

It's similar for the random access test, with 89MB/sec read and 72MB/sec write speeds. These results are less than half that of the next drive up, the Crucial P5 Plus.

Moving on to the PCMark 10 test, the WD Green SATA drive scored 399 in the System Disk benchmark and 519 in the Data Disk benchmark. Again, that's less than half the score of the drive above. These demonstrate that this isn't a drive for modern computing.

In fact, given that you're likely to have a PC with PCI-E Gen3 or Gen4 support, this drive is so slow as to be worth ignoring completely. Even if you only have first- or second-generation PCI-E, then this drive would still be too slow compared to the competition.

The only place this drive might be useful is in an external SSD enclosure, although you would get faster speeds from a Gen3 drive even in this case.

There are no TBW figures for drive endurance, with WD quoting this drive as being able to operate for one-million hours MTTF (Mean Time to Failure). It's not as useful a figure, but like all SSDs, the WD Green will likely outlive its required lifetime.

Ultimately, this drive shows that the old SATA interface can't cut it in modern computers, and while the initial prices may be enticing, it's worth spending more to buy something newer that runs on PCI-E.

SATA DRIVES

Serial ATA drives are now showing their age in terms of speed, but they still offer an easy way to expand storage.

You can still buy a SATA drive, but no new models are available .

At the start of this Labs, we said that SATA drives couldn't cut it any more. While SSD SATA drives are much faster than their mechanical counterparts, they're still exceptionally slow by modern standards; just look at the WD Green SATA M.2 drive opposite. That said, a SATA drive is better than nothing if you have an older laptop or a desktop computer that needs more storage space and has no spare M.2 ports.

We haven't reviewed any new models in this group test for one simple reason: there aren't any. The market has hit the limit of what SATA can do. Simply put, there will be no improvements in this technology, and the best drives for the connection have already been released.

The issue is that the SATA interface is slow and designed for mechanical drives. Using faster memory chips and saddling them with a SATA interface would be pointless, which explains why there's been no further development of SATA SSDs.

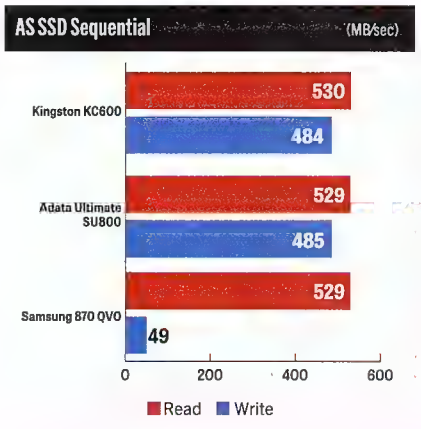
To save you time looking up what's available, we've included here some details of the best SATA SSDs from the previous Labs test. All three scored four out of five originally, and all are still currently available.

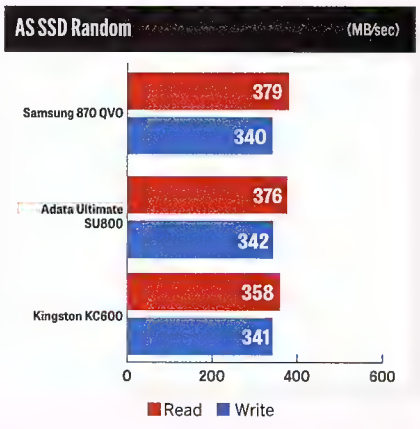
There's very little between them in terms of performance, and the minor differences in speed make it hard to choose one drive over another. The main differences are in price, and the best thing you can do is buy the largest drive you can afford for the least amount of money.

Above, we've got the key information in the table, while the performance graphs show on the left you how the drives stack up and let you compare the performance of SATA drives to the M.2 NVMe drives we've reviewed elsewhere.

SATA SSDs

	Adata Ultimate SU800	Kingston KC600	Samsung 870 QVO
Price	$198	$159	$120
Capacity tested	1TB	1TB	2TB
Other capacities available	128GB, 256GB, 512GB, 2TB	256GB, 512GB, 2TB	1TB, 4TB, 8TB
Warranty	5yr	5yr	5yr
Memory cell type	TLC	TLC	QLC
Formatted capacity	954GB	954GB	1,863GB
Endurance as reviewed	800TBW	600TBW	720TBW
Hardware encryption	✗	✓	✓



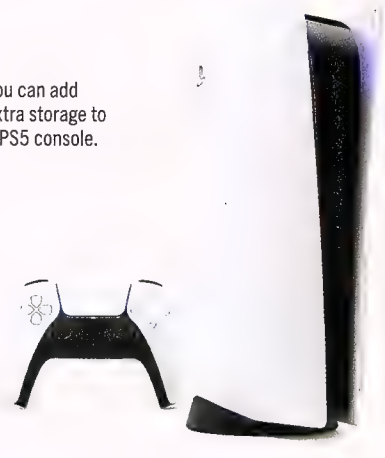


CAN M.2 DRIVES BE USED ANYWHERE ELSE?

As well as being used in external SSD enclosures, M.2 drives have made their way into the latest games consoles: the Xbox Series X/S and the PlayStation 5. The latter in particular can be upgraded with new fast storage, to give you extra space for games downloads.

Sony recommends you fit an SSD with a heatsink or heat transfer sheet. Some models ship with one, but third-party add-ons are also available. When fitting a heatsink (or using a model that has one already), it's important that the drive doesn't exceed the maximum height (11.25mm).

Installing an SSD doesn't affect your warranty, provided that you install a drive that meets the requirements listed. Fortunately, most manufacturers make this easy by stating on the SSD's product page whether it's compatible with the PS5 or not.



You can add extra storage to a PS5 console.

HOW WE TEST

Details of the speed tests we put each drive through, and how we determine the winners

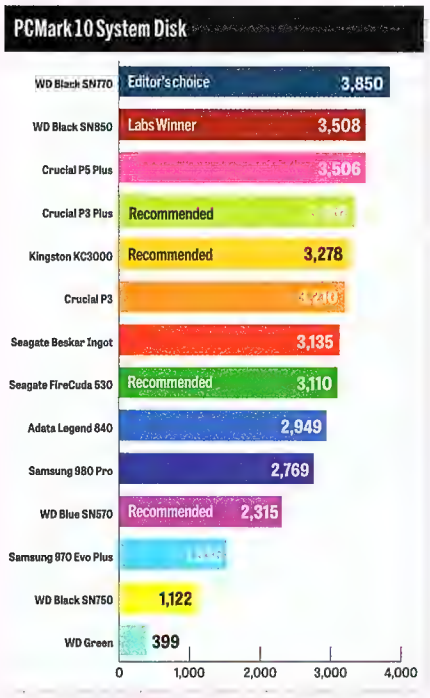
We used two tools to thoroughly test the performance of each drive in this month's Labs. The first was the synthetic AS SSD benchmark, which measures raw sequential read and write speeds for each drive – giving an indication of how quickly it can load and save large files – as well as random-access 4K operations across 64 simultaneous threads, showing how it copes with heavy demand.

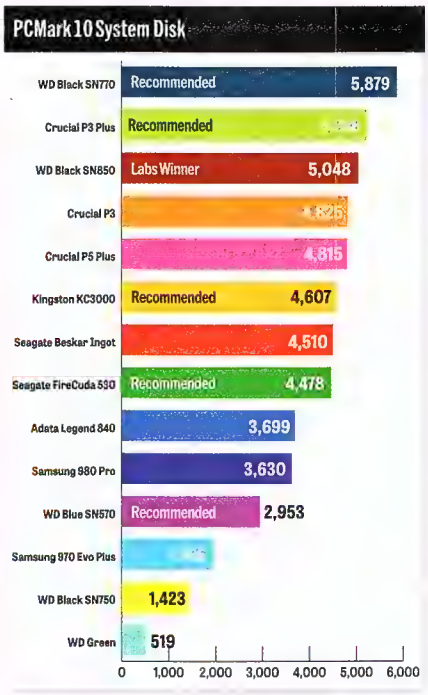
We also use the PCMark 10 storage benchmark suite to assess real-world performance. These tests use "traces" – captured sequences of read and write operations generated by real desktop activities – to put every drive through a standardised workload.

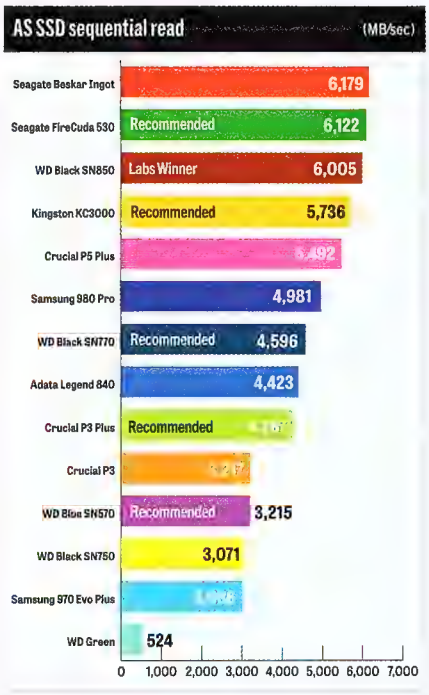
The system drive test includes booting Windows, launching and using applications such as Adobe Photoshop and Microsoft Excel, loading up *Battlefield V*, *Call of Duty: Black Ops 4* and *Overwatch*, and copying data files both to and from the target disk. We also perform the data drive test, which focuses on file-copy performance. Both benchmarks produce the absolute performance scores you see here.

Of course, performance isn't the only consideration: value is of the greatest importance.

We also look at any extra features such as hardware encryption or bundled software. Based on all of these considerations, we award each product a star rating out of five.


PCMark 10 System Disk
WD Black SN770 Editor's choice 3,850
WD Black SN850 Labs Winner 3,508
Crucial P5 Plus 3,506
Crucial P3 Plus Recommended
Kingston KC3000 Recommended 3,278
Crucial P3
Seagate Beskar Ingot 3,135
Seagate FireCuda 530 Recommended 3,110
Adata Legend 840 2,949
Samsung 980 Pro 2,769
WD Blue SN570 Recommended 2,315
Samsung 970 Evo Plus
WD Black SN750 1,122
WD Green 399
0 1,000 2,000 3,000 4,000


PCMark 10 System Disk
WD Black SN770 Recommended 5,879
Crucial P3 Plus Recommended
WD Black SN850 Labs Winner 5,048
Crucial P3
Crucial P5 Plus
Kingston KC3000 Recommended 4,607
Seagate Beskar Ingot 4,510
Seagate FireCuda 530 Recommended 4,478
Adata Legend 840 3,699
Samsung 980 Pro 3,630
WD Blue SN570 Recommended 2,953
Samsung 970 Evo Plus
WD Black SN750 1,423
WD Green 519
0 1,000 2,000 3,000 4,000 5,000 6,000


AS SSD sequential read (MB/sec)
Seagate Beskar Ingot 6,179
Seagate FireCuda 530 Recommended 6,122
WD Black SN850 Labs Winner 6,005
Kingston KC3000 Recommended 5,736
Crucial P5 Plus
Samsung 980 Pro 4,981
WD Black SN770 Recommended 4,596
Adata Legend 840 4,423
Crucial P3 Plus Recommended
Crucial P3
WD Blue SN570 Recommended 3,215
WD Black SN750 3,071
Samsung 970 Evo Plus
WD Green 524
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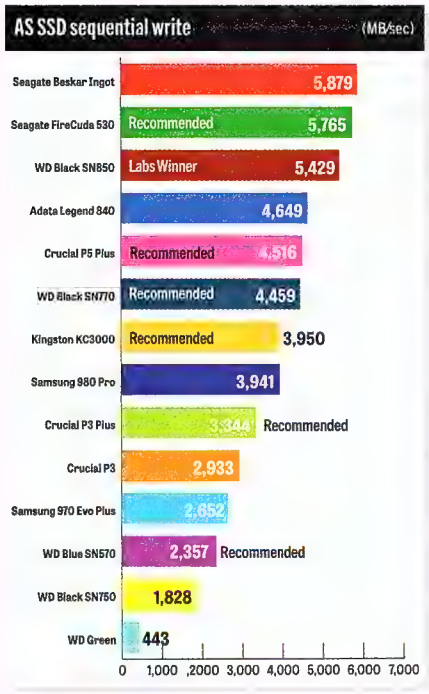
AS SSD sequential write (MB/sec)
Seagate Beskar Ingot 5,879
Seagate FireCuda 530 Recommended 5,765
WD Black SN850 Labs Winner 5,429
Adata Legend 840 4,649
Crucial P5 Plus Recommended
WD Black SN770 Recommended 4,459
Kingston KC3000 Recommended 3,950
Samsung 980 Pro 3,941
Crucial P3 Plus Recommended
Crucial P3 2,933
Samsung 970 Evo Plus
WD Blue SN570 2,357 Recommended
WD Black SN750 1,828
WD Green 443
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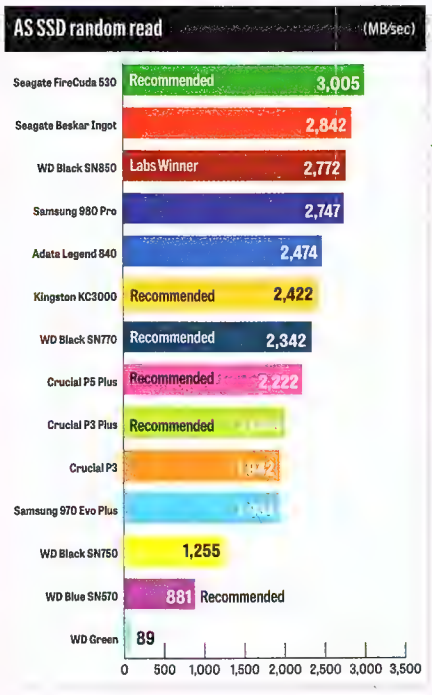
AS SSD random read (MB/sec)
Seagate FireCuda 530 Recommended 3,005
Seagate Beskar Ingot 2,842
WD Black SN850 Labs Winner 2,772
Samsung 980 Pro 2,747
Adata Legend 840 2,474
Kingston KC3000 Recommended 2,422
WD Black SN770 Recommended 2,342
Crucial P5 Plus Recommended
Crucial P3 Plus Recommended
Crucial P3
Samsung 970 Evo Plus
WD Black SN750 1,255
WD Blue SN570 881 Recommended
WD Green 89
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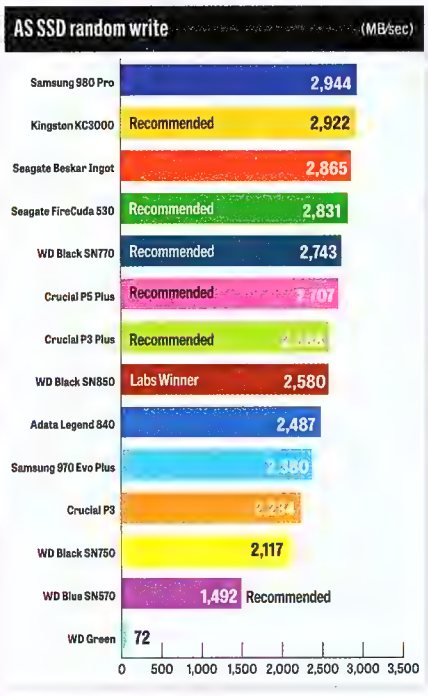
AS SSD random write (MB/sec)
Samsung 980 Pro 2,944
Kingston KC3000 Recommended 2,922
Seagate Beskar Ingot 2,865
Seagate FireCuda 530 Recommended 2,831
WD Black SN770 Recommended 2,743
Crucial P5 Plus Recommended
Crucial P3 Plus Recommended
WD Black SN850 Labs Winner 2,580
Adata Legend 840 2,487
Samsung 970 Evo Plus
Crucial P3
WD Black SN750 2,117
WD Blue SN570 1,492 Recommended
WD Green 72
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View from the Labs

Don't get sucked into comparing specs and choosing the very top models, argues David. Ultimately, it's size and value for money that matter.

It's almost impossible to find a new computer or laptop running a mechanical hard disk. The technology now seems to be relegated to hard disk TV recorders, such as Sky Q, and NAS drives. Everyone else has gone solid state, and that's for good reason: the drives are faster, use less power, take up less room and make no noise.

With the move has come the issue of more choice. Mechanical hard disks were, at least, simple. Sure, there were some variations in speed and transfer rates, but looking back, the actual differences between drives were minor. For the most part, you could make your decision based on the capacity you needed, and chuck in another hard disk when that filled up.

For a long time, SSD owners would look at the price they'd paid for their drive and cry at how little storage that bought them. That's largely gone now, because SSDs have at least caught up with mechanical capacity, while prices for 1TB drives (a sensible amount of storage for most people) are no longer eye-watering.

But there's still the issue of speed. The difference between the fastest and slowest SSDs is vast. Then there are a whole lot of other choices to make, including whether upgrading to that 2TB drive is really worth the extra cash, and which version of PCI-E you should be buying.

The difference between the fastest and slowest SSDs is huge.

Life has become a lot more complicated, it would seem, which means it's worth spending as much time choosing storage as we would a processor or motherboard. Ask yourself this: what's more important about your computer, what it physically is, or what it stores? After all, our photos, documents and lives are all digital, so storage is just about the most important thing we will buy.

The thing is not to get caught up too much on the specs, but to compromise and get the right drive for you. The fastest SSD will only ever go flat out if you have the kind of rig and applications to push it that way. Is it worth, say, compromising on space to get faster access to a drive that will be filled immediately? I'd say it isn't.

Benchmarks are important, but the reviews here go into the detail and nuance of finding the right drive. The best advice I can give is to choose the right amount of storage first, then find the fastest drive you can afford, rather than doing it the other way round.

EXTERNAL DRIVE ENCLOSURES

Want to expand your storage using an external drive? It's easy to do it yourself.

Hunt through the accessory pages of your favourite retailer and it doesn't take long to find the external M.2 SSD enclosures, which turn an SSD into an external drive. That seems like a good way to build fast external storage, but there are a few things to watch out for.

First, you need to have the right type of enclosure for the SSD you're thinking about using. The cheaper enclosures usually only support SATA drives, while the more expensive ones will support faster NVMe drives.

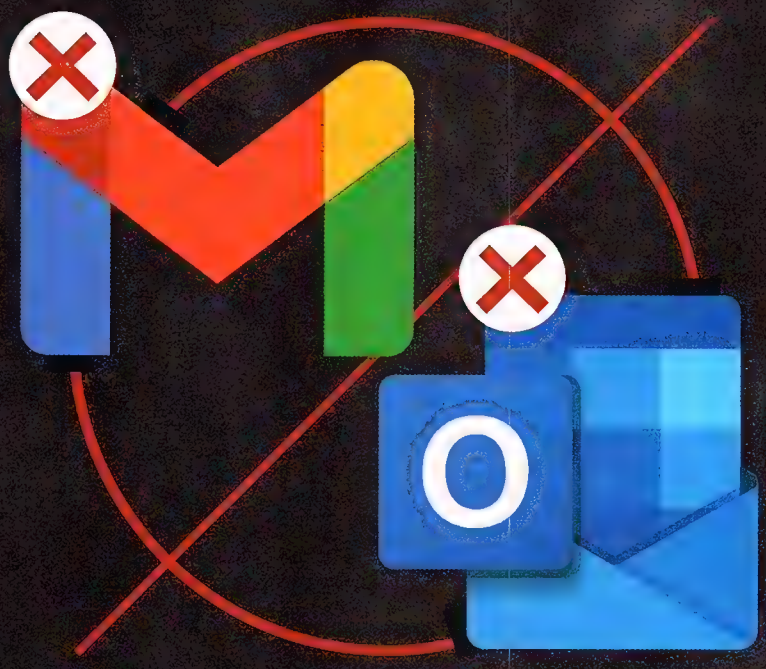
Second, you need to make sure that the enclosure you pick will take the right size drive. Most SSDs are 2280 models, so that's likely the size of enclosure that you need.

Watch out for speeds. Most USB-A and USB-C ports top out at 10Gbits/sec, which is around 1,250MB/sec. That's fast by external standards, but slow even for a PCI-E Gen3 SSD, and very slow for a PCI-E Gen4 SSD. As such, it's not worth buying a fast SSD for an external enclosure, as you'll be overpaying to get a fraction of the speeds.

We find that enclosures are a good idea in two circumstances. First, they're useful for upgraders that don't have a spare M.2 slot. The old drive can be plugged into the enclosure, and data copied to the new drive. Second, enclosures are useful for anyone that has upgraded and has a spare M.2 drive lying around – an enclosure is cheaper than an external SSD.

External drive enclosures are useful if you don't have a spare M.2 slot.

Rarely, however, do an enclosure and M.2 drive bought separately make for better value than just buying an external SSD. ■



FEATURE

Stop using Gmail & Outlook

Don't stick with a big-name webmail service just because Google and Microsoft want you to. Robert Irvine explains why you should switch your email to a better, safer and more private provider.

WHAT YOU CAN DO

- Stop Google and Microsoft spying on your email usage
- Encrypt messages so only the recipients can read them
- Block all spam and stop safe senders being blocked
- Automatically remove hidden trackers from emails
- Access Gmail and Outlook through an alternative inbox
- Set your private emails to expire after a specific time
- Keep using Google tools without a Gmail address

Gmail and Outlook may be the most popular webmail services, but as with Chrome and Edge – two other Google and Microsoft tools – that doesn't necessarily mean they're the best. They're certainly far from the most private and secure, not only because their parent companies are notorious for collecting users' data, but also because their high-profile nature makes their accounts prime targets for hackers. For example, back in August, Google reported that an Iranian cyber-warfare group was specifically stealing data from Gmail and Outlook users (tinyurl.com/APC516iran).

Having an account with one of these two services is undoubtedly convenient, especially for syncing your details, content and preferences across multiple Google and Microsoft devices, but – as we explain in this feature – other email providers offer stronger protection against snoopers, scammers and spammers.

Here we recommend the best alternative webmail services to Gmail and Outlook – all of which are more private, offer most of the same features and receive less junk mail. If ditching your current email address seems like too much trouble, we also suggest the best ways to send and receive messages without using Google and Microsoft's websites and apps.

As all the services we've included here are free (though some offer paid-for upgrades), you can use one as your secondary email account until you're ready to switch from Gmail or Outlook.

WHY YOU SHOULD STOP USING GMAIL & OUTLOOK

Gmail and Outlook collect your personal data

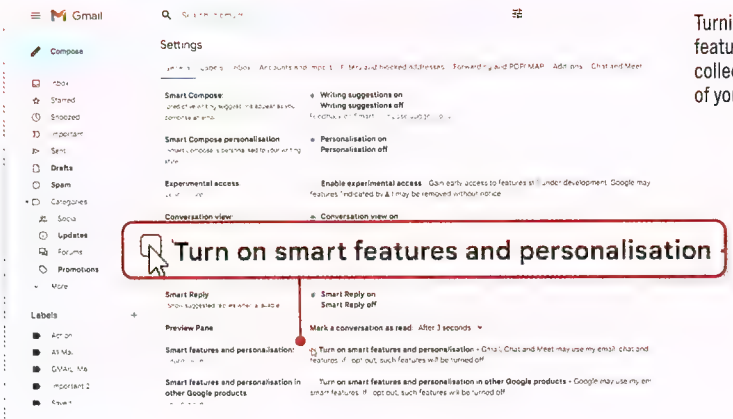
Google no longer reads the content of your emails so it can target you with ads – a controversial practice it stopped in 2017 – but it still monitors your Gmail account and collects data about how you use the service. This includes details of when you send messages, who you send them to and where you send them from. It also checks the content of incoming messages to determine their importance and sort them into categories such as Promotions and Social, and – more invasively – logs your purchases, delivery tracking numbers and travel bookings.

Your Gmail emails are scanned using AI algorithms rather than by humans, which allows the service to detect and block spam, phishing scams and malware, but this compromises your privacy by automatically linking information in messages with your Google account. This is especially true if you've enabled Gmail's 'smart' features such as Smart Compose, which makes suggestions as you type, and Smart Reply, which provides quick responses to emails so you don't need to type them manually.

You can disable these features in your account settings on the Gmail website (click the cog icon in the top-right corner and choose 'See all settings') or in the Gmail mobile app (tap the three-line menu button and select Settings). Deselect the option 'Turn on smart features and personalisation' (see screenshot above right), choose 'Turn off features' and reload Gmail to switch off Smart Compose, Smart Reply, Nudges (which suggests emails to reply to) and other AI tools. This will limit the data Google collects about you through Gmail – but to prevent it completely, you need to switch to a more private email provider.

Similarly, Microsoft doesn't scan your Outlook emails for advertising purposes, but it does collect data about how you use the service and uses AI to 'improve your user experience'.

To limit the latter, click the Settings cog on the Outlook website, select 'View all Outlook settings' and choose 'Compose and reply'. Deselect the options 'Offer suggestions based on keywords in my messages' and 'Show suggested replies'. In the Outlook app, tap your profile picture then the Settings cog, select your account and switch off 'Suggested replies' and 'Text predictions'.



Turning off Gmail's smart features will stop it collecting at least some of your personal data.

Gmail and Outlook don't provide reliable encryption

Although Gmail offers encryption over an HTTPS connection when you're reading and writing messages, your emails can still be intercepted by third parties. This is because Gmail uses an encryption protocol called Transport Layer Security (TLS), which only secures your messages in transit if the recipient's email service also supports TLS. Once your email arrives at its destination, the privacy of its content depends on the encryption used by the other person – TLS only encrypts the connection, not the message or attached files. Additionally, Google holds the encryption keys to your emails, which means it can easily decrypt them and pass their content to third parties such as government agencies.

One way to protect your Gmail emails is to click the 'Toggle confidential mode' padlock icon at the bottom of a Compose window. This prevents the recipient from forwarding, copying or downloading the content, and lets you set the email to expire after a specific length of time and lock it with a passcode (see screenshot below). However, Google will still be able to access your messages, even when they've expired or been locked.

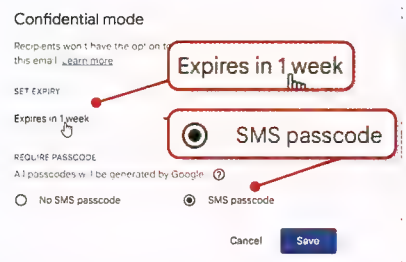
Outlook only offers end-to-end encryption for your emails if you pay for a Microsoft 365 subscription. Without one, it uses the same unreliable TLS encryption as Gmail.

Gmail and Outlook's spam filters are getting worse

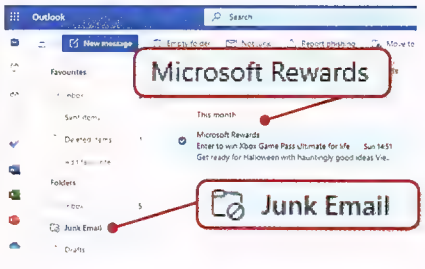
Despite Gmail's clever AI algorithms, many users have recently reported seeing more spam emails and phishing scams in their inboxes. This means that either spammers are finding ingenious new ways to bypass Gmail's filters, or Gmail is becoming less effective at detecting junk messages – or both.

It's also increasingly detecting 'false positives', when legitimate emails are misidentified as spam because they look unsafe or are "similar to messages that were identified as spam in the past". This can result in you missing important communications, unless you remember to regularly check your Spam folder and mark the messages as safe or 'not spam'.

Outlook's junk mail filters are even worse, and phishing emails often slip through simply because they appear to come from a reputable company such as Amazon or PayPal. As with Gmail, messages erroneously end up in the Junk Email folder even when you mark their senders as being trustworthy – we've even seen emails from Microsoft suffer this fate (see screenshot below).



Gmail's confidential mode doesn't prevent Google from accessing your messages.



Is Microsoft spamming its own users? Outlook's Junk Mail filter clearly thinks so.

WHICH EMAIL SERVICE SHOULD YOU USE INSTEAD?

EDITOR'S CHOICE

Proton Mail

proton.me/mail

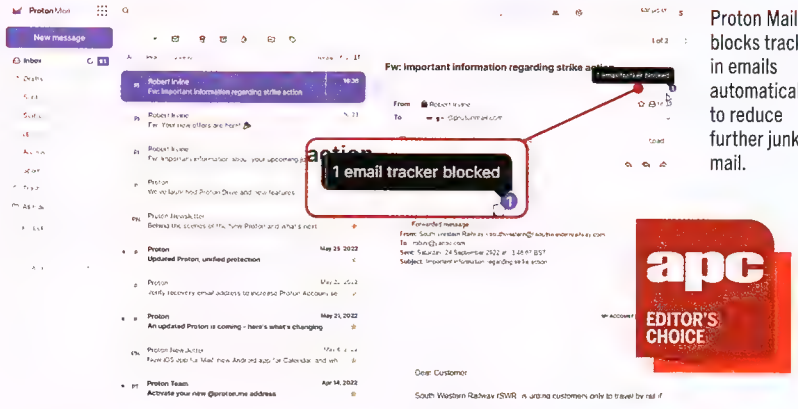
What we like

Whether you use it as your main webmail provider or as a secondary account for sensitive messages, email services don't come more private than Proton Mail. You don't need to provide any personal information when setting up an account, and your IP address isn't logged, so you can send and receive messages in comfortable anonymity.

Justifying its claim that "our top priority is keeping your data safe", Proton Mail uses powerful PGP (Pretty Good Privacy) encryption to protect the contents of your messages so that only you and the recipient can read them. Emails are encrypted automatically in your browser, or Proton's Android and iOS apps, before they're sent to the company's servers and aren't decrypted until received by the other person. However, this end-to-end encryption only works if the recipient is using Proton Mail or another PGP tool. If not, you can password-protect your messages to prevent interception and set them to expire after a specific time (see page 76 to find out how).

Proton Mail also insists on 'zero access encryption', which means that – unlike Gmail and Outlook – it can't read or grant anyone access to your messages. The company is based in Switzerland, so it's outside the jurisdiction of the 'Fourteen Eyes' surveillance alliance and can't be ordered to share its users' data with intelligence agencies. Usefully, any contacts you save to your account are also encrypted, so only you can view their details.

Another welcome privacy feature blocks trackers in emails to stop companies and spammers seeing when and where you open their messages, and using that information to target you with junk mail.



Proton Mail blocks trackers in emails automatically to reduce further junk mail.

To get this option in Gmail and Outlook, you need to install a browser extension but it's enabled by default in Proton Mail, helpfully tells you how many trackers it's removed (see screenshot above) and lets you load 'remote content' such as images in messages without being tracked. ProtonMail's simple, attractive interface makes it even easier to use than Gmail and Outlook, and can be customised with seven different themes – including two dark modes, Carbon (see screenshot below) and Monakai – and by switching between Compact and Comfortable layouts (just like Gmail).

What we don't like

Proton Mail's free plan limits you to 500MB of online storage, which is shared across the other services included with your Proton account: Drive, VPN and Calendar. This is upgraded to 1GB once you've completed certain actions, such as importing emails or contacts, but it's still pretty stingy.

You're also restricted to having one '@proton.me' or '@protonmail.com' email address, sending 150 messages a day and attaching files of up to 25MB. You can increase these amounts and unlock extra features by paying €3.99 (~$6.17) per month for Proton Mail Plus or €9.99 (~$15.44) per month for Proton Unlimited, but you get more flexibility – though much less privacy – from the free versions of Gmail and Outlook.

HIGHLY RECOMMENDED

Tutanota

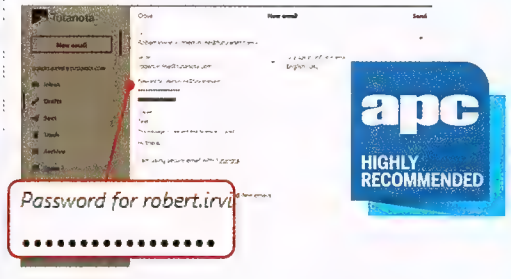
tutanota.com

What we like

Describing itself as the "world's most secure email service", Tutanota – which is Latin for 'secure message' – comes a very close second to Proton Mail. It provides most of the same privacy features, along with some useful options of its own, and its cheapest paid-for plan costs from just €1.20 (~$1.85) per month. However, this offers the same amount of online storage (1GB) as the free version, whereas a Proton Mail subscription gives you 15GB.

As well as applying end-to-end encryption to your emails so that only you and the recipient can read them, Tutanota encrypts their subject lines to hide all indication of what you're writing about. As with Proton Mail, the company can't decrypt your messages and doesn't log your IP address, and helpfully encrypts your contacts and calendar, too. You can send encrypted emails to people who aren't using Tutanota, by providing a password for

Customise Proton Mail with themes including Carbon dark mode, which protects your eyes at night.



Tutanota encrypts your emails with a password that the recipient needs to enter.

the recipients to enter (see screenshot below left), but unlike Proton Mail, there's no option to set your messages to expire.

Where Tutanota excels is in its support for different devices, with free apps for Windows, macOS, Linux, Android and iOS, in addition to its website, which ensures you can always send and receive private messages wherever you are. Its interface is even more pared-down than Proton Mail's, though this means it lacks features such as being able to 'star' important messages.

What we don't like

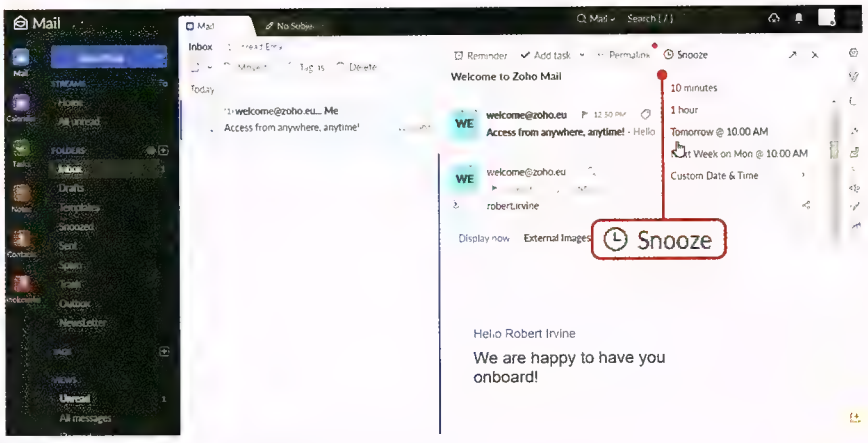
Tutanota is based in Germany, which is one of the Fourteen Eyes countries, so your data could feasibly be passed to the authorities if legally demanded – though it is protected by GDPR legislation. While the service does a good job of blocking ads and trackers in emails, its spam filter is less accurate than Proton Mail's, sometimes failing to recognise junk mail while marking trustworthy senders as spam.

Zoho Mail

www.zoho.com/mail

What we like

Although Zoho Mail is primarily aimed at businesses, it includes plenty of useful features for home users and – unlike Gmail and Outlook – you'll never see any ads in your inbox. Sign up for its free Personal Email plan to get 5GB of storage (10 times the amount offered by Proton Mail's free version) and send email attachments of up to 20MB. If that's too restrictive for your file-sharing needs, Zoho Mail's cheapest paid-for plan, Mail Lite, increases the limit to 250MB and costs a mere $1.65 per month.



Like Gmail, Zoho Mail lets you 'snooze' important emails to deal with later.

Notable tools include the ability to schedule emails to send at the time and date of your choice, or on a recurring basis; options to 'snooze' messages to deal with later (see screenshot above) and set reminders so you don't forget; and a Undo Send function that lets you cancel emails up to 30 seconds after you click Send. Best of all, if you want some of the privacy provided by Proton Mail and Tutanota, you can use Zoho Mail's SecurePass Email feature to make messages expire after a specific time, prevent them from being forwarded, printed or copied, and protect them with an OTP (one-time password) code, which is sent separately to the recipient. Zoho Mail also offers excellent spam controls, and lets you block unwanted messages by email address, domain and language.

What we don't like

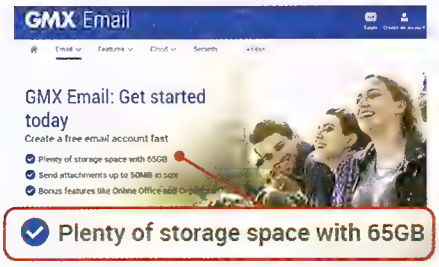
Compared with our Editor's Choice and Recommended award winners, Zoho Mail suffers from a cluttered interface, with icon-packed toolbars on either side of your inbox. Tools such as Zoho Meeting and Projects might be useful to business users, but they're distracting for the rest of us, as is the Streams feature for team collaboration. Also annoying is that your free email account can only have a 'zoho.eu' address, not 'zoho.com' or 'com.au'.

BEST OF THE REST

GMX

www.gmx.com

GMX gives you a whopping 65GB of email storage for free (see screenshot), a 50MB file attachment limit and end-to-end encryption through its Mailvelope PGP extension for Chromium and Firefox browsers. It also offers online office tools for creating and editing documents, and simple apps for Android and iOS. On the downside, it's supported by annoying ads for products from GMX and its partners, which make its web interface tiresome to use.

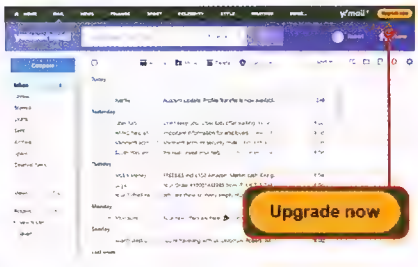

GMX Email
GMX Email: Get started today
Create a free email account fast
Plenty of storage space with 65GB
Send attachments up to 50MB in size
Bonus features like Online Office and Cryptpad
Plenty of storage space with 65GB

GMX gives you 65GB of storage for free but its ads can be annoying.

YAHOO MAIL

yahoo.com

The free version of Yahoo Mail is blighted by the same problems as Gmail and Outlook, including inbox ads, poor spam filtering and unreliable TLS-only encryption, but its 5TB of storage is undeniably impressive. Its recently redesigned mobile apps are pretty good, too. Upgrading to Mail Plus for $5 (see screenshot) removes ads, makes it easier to block spammers and lets you protect your privacy using disposable email addresses.



Yahoo Mail reserves several of its best features for its paid-for version.

MAILFENCE

malifence.com

Like Proton Mail and Tutanota, the Belgium-based Mailfence places a strong emphasis on privacy. It provides end-to-end encryption (see screenshot), blocks ads, trackers and spam, and uses digital signatures to prevent scammers from faking your email address. However, its free version offers few other features, so you'll need to pay from €2.40 (~$3.70) a month to make the most of the service, and be able to use its Android and iOS apps.

Mailfence provides end-to-end encryption but is light on other features.

BEST ALTERNATIVE WAYS TO ACCESS GMAIL & OUTLOOK

Thunderbird

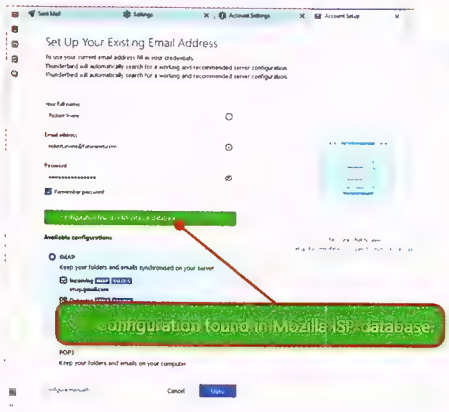
www.thunderbird.net

Rather than ditch Gmail or Outlook for another service, you can access your account through an alternative email client. This will give you a cleaner inbox that's free of adverts, tracking and spam, and saves you opening your browser each time you want to check your mail.

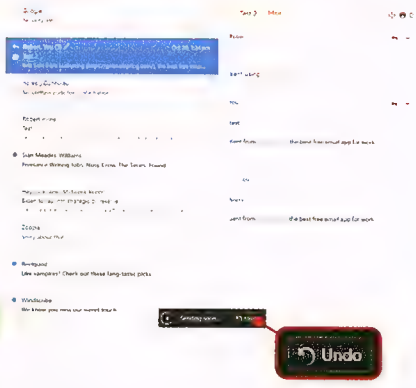
Mozilla's free email client Thunderbird is the best tool for this purpose and its recent update (to version 102) makes importing messages and contacts from Google and Microsoft's webmail services very straightforward.

If you already use Thunderbird and want to sync either service, click the Settings button in the bottom-left corner, choose Account Settings and select Add Mail Account in the Account Actions menu. Enter your name, Gmail or Outlook email address and password, click Continue and Thunderbird will automatically detect the required server configuration settings (see screenshot above right). Click 'Done', log into your Gmail or Outlook account and grant Thunderbird access. Click 'Finish' to download all the messages from your Inbox and other webmail folders.

Thunderbird has several advantages over Gmail and Outlook, including robust spam filters and phishing protection, automatic blocking of trackers, and a tabbed interface you can customise using themes and useful add-ons. It also supports end-to-end encryption for your emails using the OpenPGP standard – see **tinyurl.com/APC515FAB** to find out how to set this feature up.



Thunderbird lets you access your Gmail or Outlook account on your desktop.



Mailspring offers plenty of handy tools, including the ability to Undo sent messages.

Mailspring

getmailspring.com

Mailspring is the closest alternative to Thunderbird for accessing your Gmail or Outlook account without using their respective websites. It has an even simpler interface that looks more like a webmail service than a desktop email program, and offers a host of handy features.

These include an Undo Send function for retrieving accidentally sent messages (see screenshot above right), a Send Later scheduling option, a powerful search tool for finding emails across all your accounts, a built-in spell checker and a choice of themes – including dark mode – so you can tailor its look to your taste.

The free version of Mailspring limits you to syncing four accounts, but this should be enough for most people. You can link your Gmail or Outlook address when you set up the program, simply by choosing the relevant service and granting Mailspring access to your account.

For more features, including unlimited accounts, read receipts and an Activity tab that shows statistics about your email usage, you can upgrade to Mailspring Pro for US$8 a month.

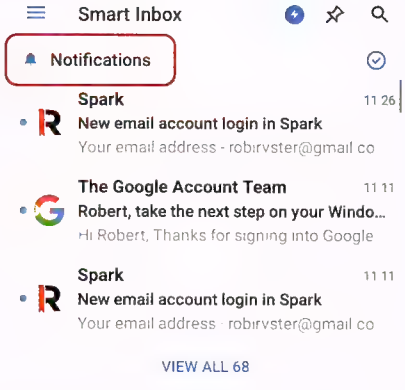
Spark Mail

sparkmailapp.com

If you use email on your phone or tablet as often as you do on your PC, Spark Mail is a great alternative to Thunderbird and Mailspring, because it offers apps for Android, iOS, Windows and macOS. Adding your Gmail or Outlook account is as easy as entering your email address, then allowing Spark Mail permission to access your data. This is safe to do because, unlike Google and Microsoft, Spark won't collect unnecessary information about you or share your data with advertisers (see box below left).

Spark Mail benefits from a clean, unified design and a 'Smart Inbox', which displays new emails in a separate Notifications section at the top of the screen (see screenshot below) and organises other messages into categories such as Newsletters and Personal. Useful features include a Gmail-style Snooze option, a Send Later function and reminders to reply to important emails. We also like the ability to save whole conversations as PDFs in a couple of taps.

Spark Mail is free and free of ads, but has a paid-for Premium plan with extra tools. This costs US$4.99 a month, but you can try it for free for seven days.



Spark Mail's Smart Inbox displays new emails in a separate Notifications area.

HOW THE GMAIL AND OUTLOOK APPS SPY ON YOU

The addition of 'privacy labels' to the Apple App and Google Play stores has revealed some slightly worrying details about the Gmail and Outlook apps for iOS and Android.

These labels confirm that Google's email service collects your location and usage data and links it to your identity for third-party advertising purposes, as well as analytics information about your contacts, purchases, search history and more. Microsoft, meanwhile, uses your email- usage data to track you, and links it to your identity for advertising and marketing purposes, for the company itself and third parties.

Although data collection can help to improve and personalise apps, Gmail and Outlook go beyond that required by other email tools.

BOOST YOUR EMAIL PRIVACY IN PROTON MAIL

Password-protect your Proton Mail messages

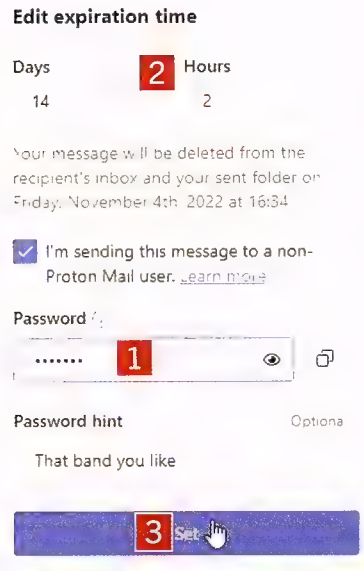
As we mentioned, one of Proton Mail's best features is the ability to encrypt private emails you send to people who aren't using the service or another PGP tool, by protecting them with a password.

To do this, either click the padlock button in the bottom-left corner of a new message window or press Ctrl-Shift-E. Enter the password you want to use (1 in our screenshot below) – you'll need to share this with the intended recipient, so you may want to click the button to copy the password to your clipboard and paste it into a separate email. Alternatively, you can share it by text message, WhatsApp or over the phone. You can also provide a hint to help the other person guess the password. Click 'Set encryption' to apply the password protection.

By default, your encrypted email will expire and be deleted from your Sent folder and the recipient's Inbox after 28 days – whether they've read it or not. To reduce the expiry time, click the Edit button, specify the number of days and hours 2, and tick 'I'm sending this message to a non-Proton Mail user'. Click 'Set' 3 to confirm and send the email.

You can make emails to other Proton Mail users expire without encrypting them with a password, because the encryption will be applied automatically.

The recipient will receive a message explaining that they have an encrypted email from your Proton Mail address. It will contain a button to 'Unlock message'. After clicking this they will be prompted to enter the password you provided, so they can read the content.



ProtonMail lets you password-protect private messages then set them to expire.

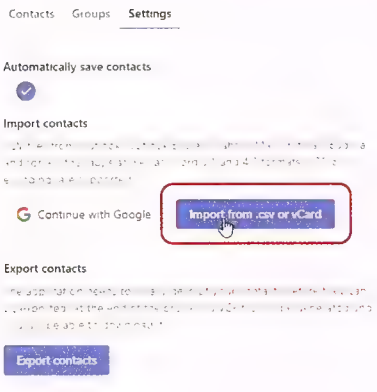
Import and encrypt contacts in Proton Mail

Proton Mail encrypts the names and email addresses of your contacts, and protects them with a digital signature so they can't be tampered with. However, it doesn't apply zero-access encryption to the data, because this would stop certain features – including auto-complete, spam filtering and search – working properly. Extra information you add to contacts, such as phone numbers and home addresses, is fully encrypted so that only you can see it, as indicated by a padlock icon.

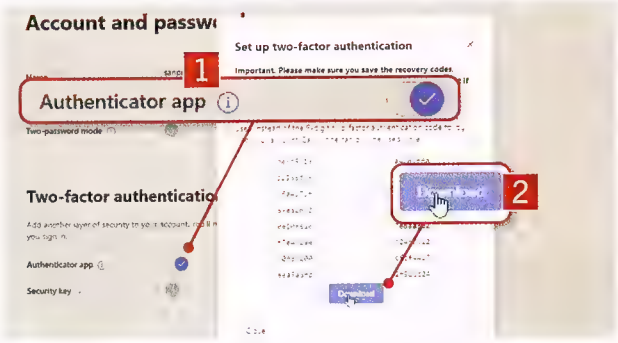
To import and encrypt your contact data from Gmail or Outlook, you'll first need to export the details as a CSV file. To do this for Gmail, go to https://contacts.google.com and select the contacts you want to migrate. Click 'Export', select Google CSV then click 'Export' to download the CSV file.

In Outlook, click the People icon in the left-hand toolbar and select 'Export contacts' in the Manage menu in the top-right corner. Click 'Export' to save your contacts as a CSV file.

Back in Proton Mail, click Contacts then Settings and choose 'Import from .csv or vCard' (see screenshot below). Select your downloaded CSV (this file is permitted to contain up to 10,000 contacts) then when you're ready click Import.



Import your contacts from Gmail or Outlook into Proton Mail to encrypt them.



Boost the security of your Proton Mail account by using two-factor authentication.

Secure Proton Mail with two-factor authentication

You can add another level of security to your Proton Mail account by enabling two-factor authentication (2FA). This ensures that only you can access your emails, should your password be somehow compromised.

To use 2FA, you must first install an authenticator app on your phone and have access to that device while logging into your account. One of the best free options is Twilio Authy (**Android www.twillo.com**). Install this app on your phone – you'll need to verify your device via text or WhatsApp message – then open Proton Mail in your desktop browser, and click Settings, then 'Go to settings'. Select 'Account and password' in the left-hand menu and switch on 'Authenticator app' (1 in our screenshot above) under 'Two-factor authentication'. Enter your Proton Mail password, click Authenticate and click Next.

You'll now be prompted to scan a QR code using the authenticator app on your phone. In Authy, tap the 'Add account' button, then Scan QR Code to activate your camera and scan the code. Authy will ask if you want to enable backups, but you can skip this by tapping the three-line icon in the top-right corner. Type the provided six-digit code into Proton Mail to enable 2FA – you can download a list of recovery codes 2 in case you lose your mobile device.

Alternatively, secure your Proton Mail account using two passwords – one to log in with and the other to decrypt your inbox. Switch on 'Two-password mode' on the 'Account and password' page, enter the first login you want to use, then click Save and type the second password. Note that Proton Mail can't access your mailbox password, so if you forget it you'll be locked out of your account.

SURVIVE WITHOUT GMAIL OR OUTLOOK

Use Google tools without a Gmail account

Contrary to popular belief, you don't actually need a Gmail account to use Google's other products and services. Although Google would obviously prefer you to have one, so it can track your data across all its tools in one place, it's not compulsory and it's possible to delete your Gmail account and use an email address from a different provider instead.

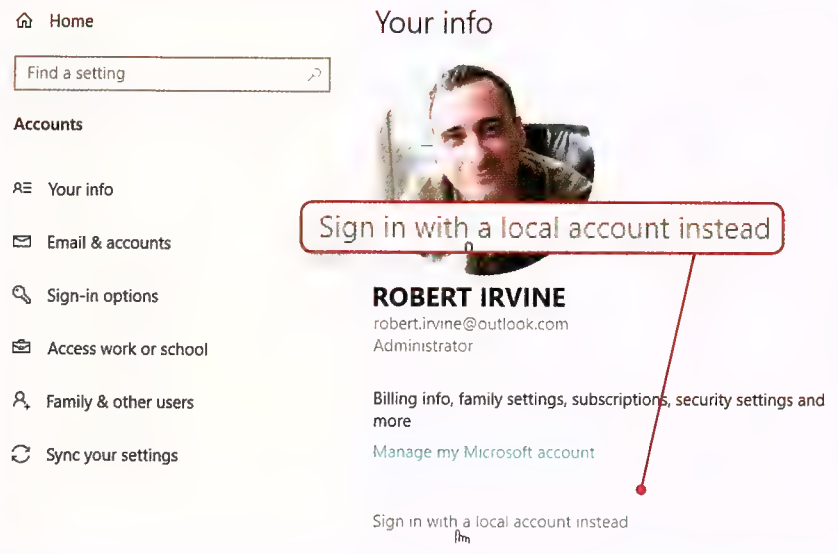
Visit your Google Dashboard page (**myaccount.google.com/dashboard**) and select 'Delete a service', then click 'Delete a service' again. Sign into your Google account with your current Gmail address and click the bin icon next to Gmail. You may want to download your emails and other Gmail data first, through Google's Takeout service (**takeout.google.com/**). Enter the email address you want to use instead, click 'Send verification email' and click the link in the message you receive. Gmail will then be deleted from your Google account.

Note that you won't be able to use some Google services without Gmail, such as the Google Play Store on your Android phone, so don't delete your account unless you're sure you can live without it.

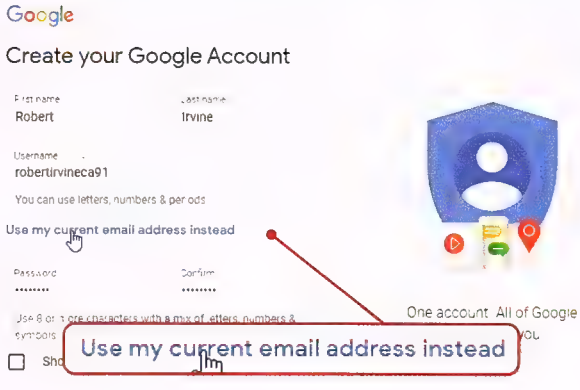
To sign up for a secondary Google account without losing access to your current Gmail inbox, visit Google's 'Sign in' page (myaccount.google.com) in a browser in which you're signed out. Click 'Create account', choose 'For my personal use' and click 'Use my current email address instead' (see screenshot below left). Enter your name, non-Gmail email address and password, and click Next to verify your account.

Use Windows without an Outlook account

If you used your Outlook account when setting up Windows on your PC, but now want to ditch it for another email service, you can switch to using a local account instead. Although this means your data from Microsoft services won't be synced across devices, it also prevents the company from tracking your activities and using your personal information to target you with ads. Additionally, because a local account stores your login details on your PC, rather than online, it puts you less at risk from hackers and data breaches.



Ditch your Outlook account and sign into Windows with a local account.



You can create a Google account using a non-Gmail email address.

To switch from a Microsoft/Outlook account to a local one in Windows 10 or 11, press Windows key-I to open the Settings app and select Accounts then 'Your info'. Click the 'Sign in with a local account instead' link (see screenshot above right) and Microsoft will ask if you're sure you want to switch. Click 'Next', enter your current Microsoft password or PIN, then choose a username and password for your local account. Click 'Sign out and finish' to confirm - this will sign you out from all Microsoft services.

When installing or reinstalling Windows 10, you can skip the requirement to sign in with an Outlook or other Microsoft email address by clicking 'Offline account' in the bottom-left and choosing 'Limited experience'.

Annoyingly, Windows 11's setup process now insists you log in with a Microsoft account instead of a local one. One way around this is to disconnect your PC from the internet when you reach the 'Sign in' screen, then click the back arrow in the top-left corner. ■

SWITCH TO 'LITE' VERSIONS OF OUTLOOK AND GMAIL

If you find the Outlook mobile app slow and bloated by features for business users, switch to Microsoft Outlook Lite for Android (via Google Play Store).

Released in August, this new version includes all the essential tools from the standard Outlook app, but is considerably smaller – around 5MB in size – and uses less memory, processing power and battery.

Outlook Lite is designed to run on low-specification Android phones, but works just as well on higher-end devices.

In contrast, Google's similarly streamlined email app, Gmail Go (via Google Play Store) can only be installed on low-specification phones that run the stripped-down Android Go mobile operating system. These include the Nokia 1.3, Nokia C21 and Alcatel 1. However, you can sideload an APK file of the Gmail Go app on any Android phone by downloading it from APKMirror (**tinyurl.com/APC515APK**).

FEATURE - PART 2

(R)evolution of Portable Audio: Things Getting Reel

The secret German invention of polyvinyl chloride magnetic tape and a surprise accidental discovery led to an entertainment revolution that lasted more than 50 years. Darren Yates *writes.*

Above: The Magnetophon tape recorder combined AC-bias recording with PVC magnetic tape during WWII (Image credit: George Shuklin, CC-BY-SA 1.0).

Below: The initial 1958 'black box' wire recorder featured three separate reels (Image credit: John Broomfield, Museums Victoria, CC-BY-4.0)

It's a sad but inevitable fact that wars bring inventions and world-changing inventions, like the cavity magnetron, weren't just limited to the Allies during World War II. For nearly 40 years, machines had been magnetically recording sound onto compact spools of very thin steel wire. These 'wire recorders' were still to have their brief heyday in the U.S. in the late-1940s and early-1950s. But in 1941, German engineers had already invented and discovered a technology combination that would revolutionise the entertainment industry around the world during the latter half of the 20th century.

The 1935 Berlin Radio Show

The idea of recording high-quality audio isn't new (just ask any podcaster), but neither are the tenants that determine recorded quality. You need a device capable of capturing sound but generates no background-noise of its own (called 'high signal-to-noise ratio'); you need the ability to capture frequencies right across the audio spectrum ('wide frequency response'); and you need a device with high linearity to capture those frequencies accurately ('low total harmonic distortion').

In 1935, the new Magnetophon tape recorder from German engineering giant AEG (Allgemeine Elektricitats-Gesellschaft) greeted the Berlin Radio Show with its new PVC (polyvinyl chloride) magnetic tape from German chemical group IG Farben/BASF. Spinning with a high one-metre-per-second tape-speed, the Magnetophon could capture much of the audio spectrum, but early recordings were said to have noticeable distortion and background noise. Over the next four years, incremental improvements were made by changing the tape's chemical formula and applying a DC-voltage to the recording process. But the greatest improvement would come largely by accident.

A chance discovery

Early tape recorders worked by applying an audio signal to a wire coil attached to a special alloy frame, collectively called a 'recording head'. The audio signal causes the wire coil to generate a magnetic field that changes with the signal. The head also has a tiny physical gap – this allows those field changes to be magnetically imprinted onto the recording tape as it passes across the head.

During 1941, two engineers at the German national broadcaster RRG received a Magnetophon recorder with a work-order to fix a fault. What they discovered wasn't a fault at all, but a chance random effect that greatly increased the audio quality. Magnetic tape is inherently non-linear, meaning that it doesn't record signals proportionally – simply making the audio signal louder on the tape by increasing its amplification just adds greater

imperfections or 'distortion' to the quality.

It turned out that the 'faulty' recorder's built-in amplifier was resonating or 'oscillating' at an ultrasonic frequency beyond human hearing. On top of that, the audio signal was being accidentally mixed in at a much lower level than this ultrasonic signal onto the tape (a process today called 'AC-biasing'). This effectively moved the audio into a more linear magnetic region of the tape, greatly reducing the distortion and for the first time, people heard the quality of magnetic tape recording.

By 1943, the tide was beginning to turn against the German forces, but continued German research resulted in the first stereo tape recorder. There is an incredible stereo recording of Beethoven's Allegro from Concerto No. 5, reportedly recorded in Berlin in 1944 on a stereo Magnetophon machine (**https://youtu.be/EY7lvuVjjX4**). Scroll to 5mins36secs and you can hear air-raid artillery low in the right channel during quieter passages. Just extraordinary (and the audio quality is superb!).

Battle Broadcasting

Newsreels during WWII brought the (albeit censored) vision of war to movie theatres around the world (legendary Australian war-correspondent Damien Parer received an Academy Award for his memorable 'Kokoda Front Line' footage). But until late-1943, much footage was largely vision-only.

One of the very first portable audio recorders was developed as an experiment and used in arguably the most trying of conditions. Two technical-sergeants of the U.S. Marine Corps, Fred Welker and Keene Hepburn, took a wire recorder, stripped out of it everything it didn't need and carried it into battle, capturing the real sounds of war. Today, the U.S. Library of Congress has this audio history of the Battle of the Marshall Islands from 1 February 1944 online (**https://tinyurl.com/apcrecorder**). The Marine Corps continued making recordings until the end of the war, many of which are now contained in the U.S. Library of Congress.

To the victors...

Meanwhile, the Allies knew about the German Magnetophon recorders before the war, but apparently had no idea about AC-biasing and PVC tape, only to discover them when they overran German forces during late-1944/early-1945. What's more, they didn't seem all that interested and it was left to U.S. army officer Jack Mullin, who legally acquired two Magnetophon recorders, 50 reels of tape and took them back with him to the 'States.

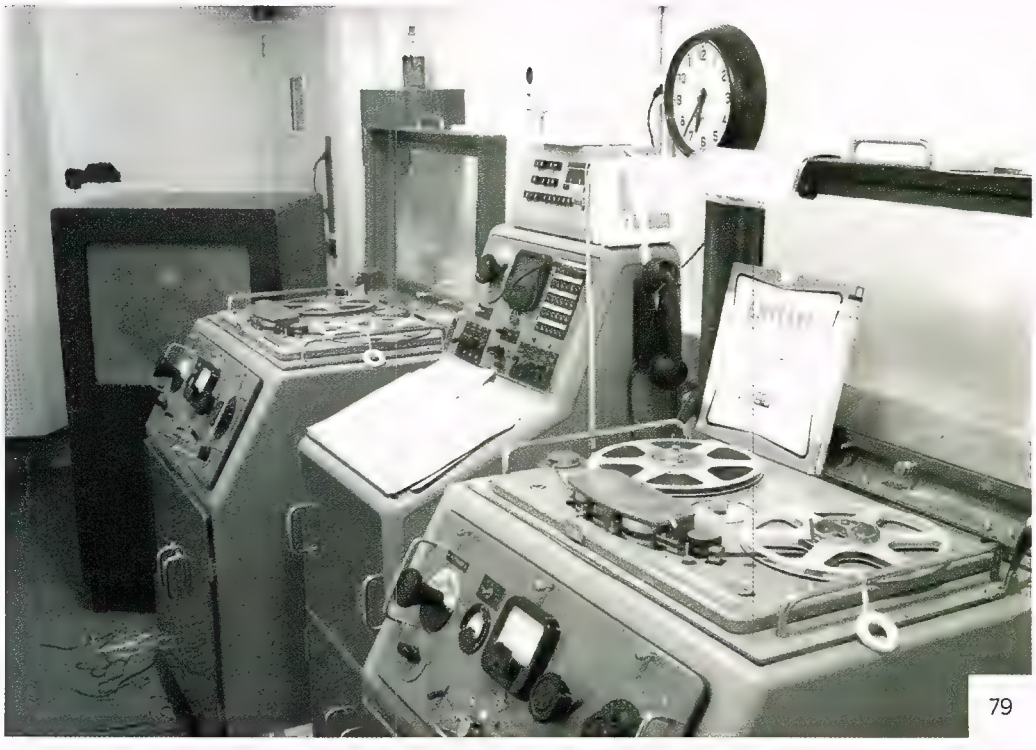
Mullin had the skill to modify and improve the machines further, but not the backing to turn them into a commercial reality. Enter singer/actor Bing Crosby. Tired of performing live radio shows and looking for a higher-quality option than the standard transcription record discs of the day, Crosby heard Mullin's machines via a 'test-taping' of one of his (Crosby's) shows. The results were so good, Crosby hired him on the spot and signed Ampex Corporation to make machines with Mullin's help. By 1948, the Ampex 200A recorder was winning over entertainment executives across the country.

Above: Wire recorders were the first 'electronic memory' to record audio (Image credit: Catalogo Collezioni, CC-BY-SA 4.0)

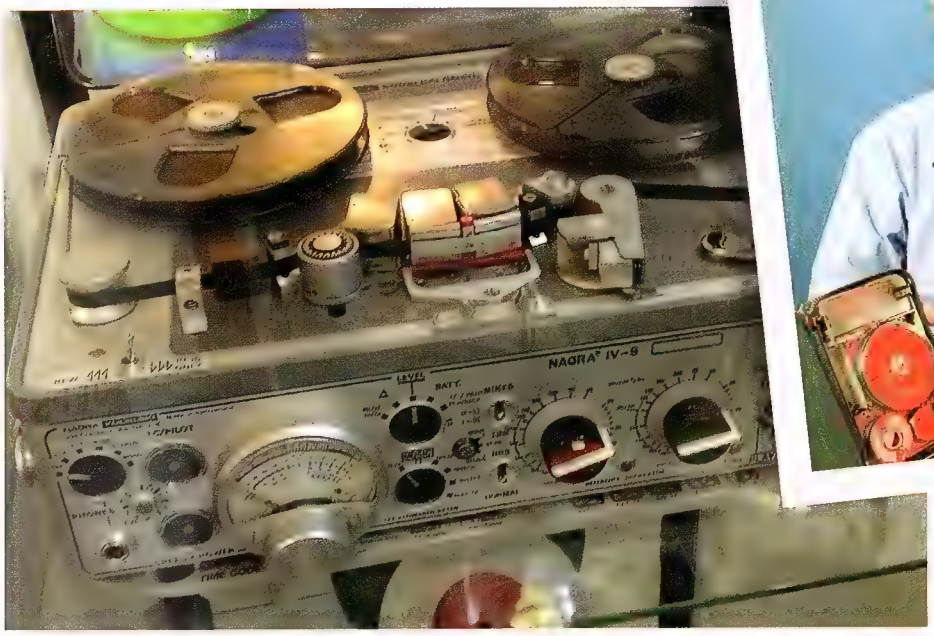
Enter the transistor

Last time, we saw how the size of 1940s radio-valves/vacuum tubes limited the ability of radio designers to shrink their designs. Tape recorders were considerably more complex and as a result, early units, like the Ampex 200A and 300 models, plus the British EMI BTR2s in England, were built in large steel console units to house the valve circuitry and motors.

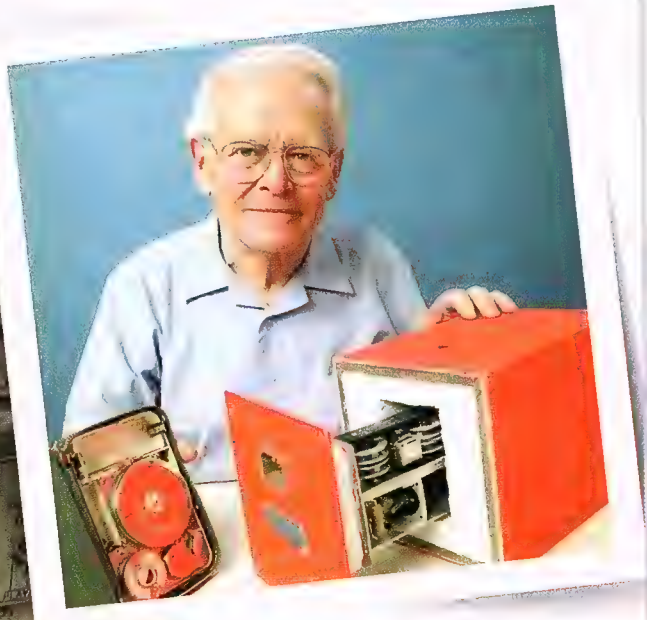
But audio recording would soon benefit from another new technology beginning to hit its straps – the transistor. Despite being invented in 1947, it took time to develop the manufacturing



Below: Music Recording giant EMI famously made its own tape recorders, like these BTR2 machines at the BBC, 1961 (Image credit: RFWilmut, CC-BY-SA 3.0).



Above: The Nagra IV-S, arguably the best portable reel-to-reel recorder ever made... (Image credit: Hens Zimmerman, Zeist, The Netherlands, CC-BY-2.0).



Above: The Australian inventor of the aircraft 'black box' flight recorder, Dr. David Warren (Image credit: Museums Victoria, CC-BY-4.0).

techniques to make transistors in quantity. However – and this is why transistors were so revolutionary – as the 1950s progressed, the size of tape recorders continued to shrink and by the end of the decade, some of the first affordable, transistorised, portable tape recorders were hitting the market.

Developed by the German 'Trix' toy company in 1958, the 'phonotrix 1' was also thought to be one of the first tape recorders used by secret agents during the Cold War.

It's a compact recorder operated by four 'D'-size batteries, with a separate speaker unit. The tape reels are a tiny 7.5cm (three-inch) and at a speed of 3.75-inches (9.5cm) per second, give you approximately 15-20 minutes of recording time.It's also a 'half-track' recorder, meaning that once the tape has been recorded, you can 'turn over' the reels and record another 20 minutes on the other side of the tape.

The 'phonotrix 2' appeared the following year with recorder and speaker combined. Trix also manufactured recorders under the 'Clarion' brand and a number of these units made their way out to Australia.

The original model had a speed control that allowed spies to tap out their Morse code messages onto tape, but play them back at higher speed when transmitting them via radio. Speeding up the transmission would make it harder for any government listening posts to find the radio source.

Below: Ampex introduced the Model 300 tape recorder in 1949 (Image credit: Cliff, CC-BY-2.0).

Australian-made

Much of the initial technical development for tape recording originated in Europe and the U.S., but we also designed and made our own tape recorders here in Australia. Arguably the most famous of these were made by Byer, a small manufacturer in South Melbourne.

The most well-known examples, the Byer 66 and 77 models, were as tough as teak – over 200 Byer 77s were brought in by the-then Australian Broadcasting Commission (now Corporation, ABC) for the 1956 Melbourne Olympics. Both units were considered portable, with the Byer 66 built into a ruggedized suitcase that could be carried between locations. The original Byer 55, launched in 1953, is believed to be the first Australian-designed tape recorder, but sadly, few examples remain today.

By 1958, another iconic Australian audio company, Rola, had taken over the business and Max Byer moved to Holbrook, in southern NSW, opening a motel. The 'Byer Fountain Motor Inn' still stands today. However, Rola would be taken over by Plessey Electronics during the 1960s and Plessey by Philips in the 1970s, as the Australian electronics industry consolidated.

Pop-culture icon

The decade between 1955 and 1965 was arguably reel-to-reel tape-recording's pop-culture moment – new magazines dedicated to tape recorders hit the newsstands and recorders were the 'PCs' of the era.

Back then, you could buy tape recorder chassis parts at wholesale, build your own electronics, put the lot into your own casework and create a brand. Many did – and many disappeared almost as quickly. However, by the early-1960s, a new wave of Japanese brands such as Sony, Sanyo and National (Panasonic) began launching compact portable tape recorders, thanks to the now fast-improving transistor market.

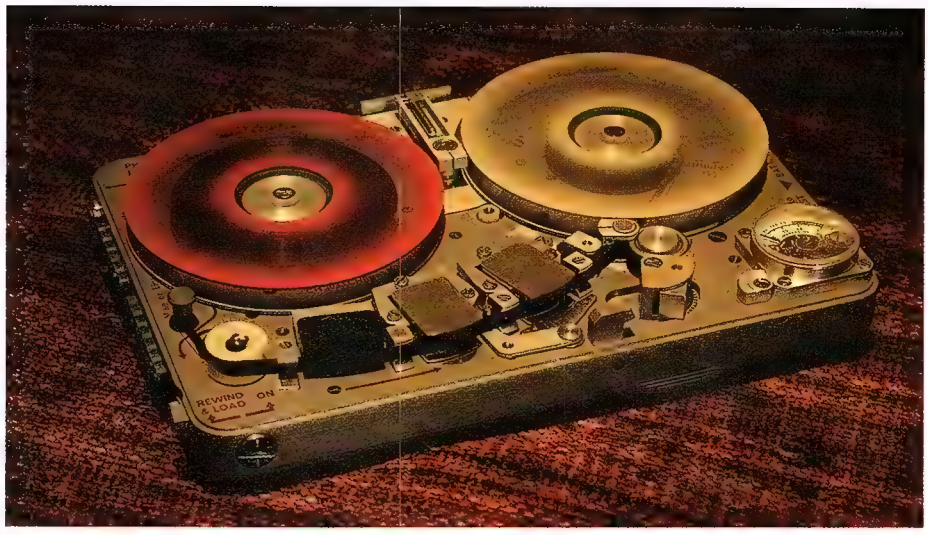
These little wonders captured the imagination and began turning up in movies and TV shows, most famously the 'spy' genre – and James Bond movies in particular (look out for the very rare Stuzzi 304B in 'From Russia With Love'). They also stole the show in each 'Mission: Impossible' TV episode.

High-Fidelity

The 1960s was also the beginning of the 'hi-fi' era, where sound quality became a much sought-after commodity, pushed along by the arrival of micro-groove long-play ('LP') stereo records and higher-quality speaker systems. Many home recordists soon realised that recording their LPs onto tape would allow them to endless play the tape, whilst keeping the LPs in pristine condition. However, analog copying was a slow and lossy system, where each copy of a copy would deteriorate the original sound. It wouldn't be until the combination of digital recording and the internet in the late-1990s that audio recording technology would give music executives nightmares.

If there's one brand that represents the 'Rolls-Royce' of portable audio recording during the 1950s-1980s reel-to-reel era, it'd be Swiss brand, Nagra. If a Swiss watchmaker decided to build a portable tape recorder, you'd still struggle to get anything better than the Nagra range. In fact, the first model, the Nagra I, was hand-made by founder Stefan Kudelski, then an electrical engineering student, when he was just 22-years-old in 1951 and featured a hand-wound clockwork motor.

New and improved models continued to appear and Nagra recorders gained a reputation for their Swiss-precision, earning them favour in Hollywood. To-date, Nagra has received two Academy Awards for its recorders. Vintage 1970s/80s Nagra tape recorders sell for a motza today as a result.



Above: The Nagra SNS, the ultimate compact spy recorder (Image credit: Hiendaudio, CC-BY-SA 3.0).

Storing computer code

By 1969, even the concept of storing computer data onto tape-reels had entered the mainstream and famously featured in the movie, 'The Italian Job', starring Michael Caine. However, the idea of storing computer data onto tape actually dates back to as early as 1951, when the UNIVAC I (Universal Automatic Computer I), a valve-powered mainframe computer was given a storage unit called the UNISERVO. In this case, the tape was metal (nickel-plated phosphor-bronze) and reportedly ripped through the machine at the speed of 2.54 metres per second or 9.1km/h.

Many of us who grew up in the 1970s and 80s will remember using a different tape format to store programs from our 'home computers' – but we'll save this for next time.

Traveling far – by tape

Apart from computer storage, there was another more serious, but equally important application for portable audio recorders. During the early-1950s, the world watched in horror as a number of De Havilland Comet passenger aircraft crashed from the sky. The remaining Comets were grounded, while experts from Australia's Department of Civil Aviation and the Aeronautical Research Laboratories met to try and discover the cause. It was Australian ARL scientist, Dr. David Warren, who, struck by the basic lack of available data, developed the flight-deck/cockpit voice recorder. The initial versions were wire recorders, later replaced by magnetic tape and finally by digital recording.

The other thing tape recorders invented was the 'letter-tape' – instead of writing letters, you could now record the family sending greetings to loved ones overseas, send the tape in the post and a few weeks later, your extended family could hear you. Given overseas phone calls, let alone plane travel, were still play-things of the 1960s' rich and famous, a small three-inch reel could give as much as 40 minute of family news. What's more, you could play it back whenever you wanted – better than a one-time phone call. It might seem quaint today, but at the time, this ability for anyone to capture sound for posterity really was revolutionary.

Above: The Phonotrix 2 was the bigger brother to the smaller unit used by spies during the Cold War (Image credit: Joe Haupt, CC-BY-SA 2.0).

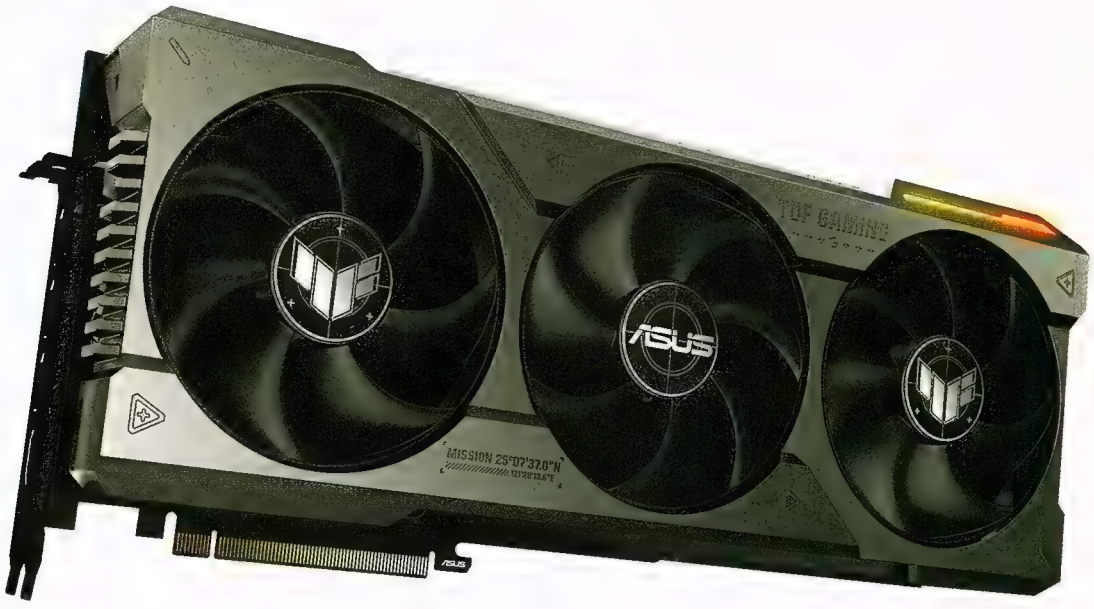
Change in the wind

Nevertheless, even while tape recording was hitting its stride in the early-1960s, a monumental change was on the horizon. The required process of 'lacing up' a tape through a tape recorder was thought to be both too complex and a time-waster for many consumers. Why not have a cartridge-style tape mechanism the user just loads into a machine? Next time, we look back at attempts to create a 'compact' tape format, culminating in one that would revolutionise portable audio and drive popular culture for nearly 40 years. ■

PC BUILDER

System News

RTX 4000 pricing woes continue. Mark Williams examines the lengths of Nvidia's greed.



Mark Williams
Mark is an IT professional with a strong interest in voiding warranties.

The hubris Nvidia continues to show towards customers reached new heights in the middle of November, with the release of its newest RTX 4080 graphics card. A fantastic card in the technical sense, but Nvidia's '80' class of graphics cards have always been the go-to for gaming enthusiasts wanting great performance at not so ridiculous pricing. That's what the '90' or Titan class of cards are for – those who want the best at any cost. The '80' class should offer a modicum of value.

With the 4000 generation, however, Nvidia is charging the same performance per dollar for the RTX 4080 as the RTX 4090, creating the situation we're in where the asking price is circa $2,400. Crazy!

The RTX 4090 can get away with its higher $3,200 price because its performance is such a leap ahead, plus the larger VRAM capacity is a great value add in productivity work. As crazy as it sounds, to anyone wanting to spend around $2,500 on an RTX 4080, the RTX 4090 starts looking like good value.

The result is a product that customers have realised is of poor value and aren't considering. The launch week for the RTX 4080 saw plenty of availability and no variant selling out which is unheard of for a new high-end Nvidia card launch. Even a month after launch our store contacts confirmed they're still barely selling.

With high-end RTX 3000 series cards formerly being the main reason for the RTX 4000 series prices being so much higher, you'd think that once they sold out the RTX 4080 will come down in price. Unfortunately, stocks of top-tier RTX 3000 cards have basically dried up, yet RTX 4080 pricing remains unchanged, leaving a huge $1,000 price gap between the RTX 3080 and RTX 4080.

With Nvidia happy to bleed customers' wallets dry, it seems we're depending on AMD to provide the panacea to this pricing headache. With the RX 7900 XT and XTX just releasing and the XTX more or less equal to the the RTX 4080 in performance, yet cost $1,619 and $1,789 respectively some US$400 less, Nvidia is about to receive a big wake-up call. One I'm sure it won't mind as it drops off all the extra cash it's making at the bank. ■

SHOP TALK

How has the RTX 4080 launch been? What are your thoughts on its pricing?

Jaimie, Leader Computers:
"The RTX 4080 has launched at an inopportune time, with interest increasing monthly, and a very heavy sticker price, most gamers looking to buy one have put purchasing plans on hold. The general cost of living is making it harder to afford a card this expensive. A slower sell-through rate at a very healthy margin for Nvidia may be far more attractive than dumping stock quickly at slimmer margins."

Richard, Aftershock PC:
"We have found the 4080s to be moving very slowly. The price is just far too high. Sales of the 4090 have been quite healthy. I believe they would start moving if they were $400-$500 cheaper. This would bring them in line with the RRP in the US of $1,300-$1,400USD which would be about $1,920-$2,060 AUD. Instead, the same GPUs are selling for around $2,460 here which is just too high (and can't be blamed on shipping which would only be a fraction of that difference)."

Market Watch

A sampling of PC systems available this month.

AUSTIN COMPUTERS OP-S00015

$2,599 | tinyurl.com/APC516AUS

Rather than going all out on the CPU front trying to sell you the latest and greatest, Austin is instead opting to offer a three-generation old CPU that games around 10 percent slower than a Ryzen 5600, which is still quite solid these days. The huge benefit of this is that the motherboard and CPU cost much less allowing Austin to drop in a much beefier GPU in the form of an RTX 3070 relative to the more expensive IJK system.

Ignoring the fact that you're buying a now-dead platform, there is some great gaming performance per dollar here.

The sole 500GB SSD may feel lean quite quickly so bear that in mind with your game library installs.

CPU: Intel i5-10600; **Cooler:** Asus ROG Strix LC 240mm RGB Liquid Cooler; **Motherboard:** MSI B560M-A Pro mATX; **Graphics:** Asus ROG Strix RTX 3070 OC 8GB V2; **Memory:** 16GB Kingston Fury Beast RGB 3200MHz DDR4; **Storage:** 500GB Kingston NV1 NVMe SSD; **Power Supply:** Cooler Master V 850W V2; **Case:** Corsair 275R Airflow.

UMART G7 INTEL I7 13700K RTX 4080

$5,499 | tinyurl.com/APC516UMA

This system is housed in the showy, spacious and easy to maintain Lian Li O11 Dynamic XL. The CPU is the perfect choice for gamers with the likes of the i9 essentially being a waste of money. The 360mm AIO is quite necessary on these hot running Raptor Lake processors so is good to see here.

Matched to it is the new RTX 4080, which runs very dear currently. You might see a good $400+ come off the asking price, through the beginning of 2023 after AMD's Radeon 7000 series drops, so waiting before you buy would be prudent.

Using DDR4 is interesting and certainly not ideal for CPU performance, though it does help offset the cost of that overpriced GPU. The 2TB SSD is the cherry on top of this RGB-lit silicon cake.

CPU: Intel Core i7 13700K; **Cooler:** 360mm AIO; **Motherboard:** Asus TUF Z690-Plus Wifi DDR4; **Graphics:** Asus GeForce RTX 4080 TUF Gaming OC 16GB; **Memory:** 32GB 3600MHz DDR4; **Storage:** 2TB NVMe M.2 SSD; **Power Supply:** 850W; **Case:** Lian Li PC-O11 Dynamic XL.

PC CASE GEAR PESTILENCE 4080

$5,599 | tinyurl.com/APC516PCC

Like the Umart system in both CPU and GPU, PCCG – whilst asking $100 more – is still trying to offset that expensive GPU by splitting the SSD capacity partially onto SATA to reduce costs. The extra $100 does get you DDR5 though so it'll be maximising CPU performance. However, the DDR5 kit is listed as having AMD EXPO RAM profile timing support, not XMP as Intel needs. Just check with PCCG before purchase that they'll supply a comparable XMP enabled kit instead.

With a more direct path airflow case than the Umart system, it compromises a little on outright looks for potentially better system cooling. Both systems however are top-notch options for dedicated gamers.

CPU: Intel Core i7 13700K; **Cooler:** Asus ROG Strix LC II 360 ARGB AIO; **Motherboard:** Asus Prime Z790-P Wi-Fi CSM DDR5; **Graphics:** Asus GeForce RTX 4080 TUF Gaming OC 16GB; **Memory:** Corsair Vengeance RGB 32GB 5600MHz CL36 DDR5 EXPO; **Storage:** Team Cardea Zero Z440 M.2 NVME PCIe Gen4 SSD 1TB, Team Vulcan Z 2.5inch SATA SSD 1TB; **Power Supply:** Phanteks AMP PH-P850G 850W; **Case:** Phanteks Eclipse P500A Airflow.

IJK SUPERIOR AMD5

$2,630 | tinyurl.com/APC516IJK

Building a new sweet spot system these days is hard with all the new products out that are still at their launch prices, especially AM5 motherboards, meaning just getting the CPU, motherboard and RAM sorted leaves little else in the budget.

This leaves IJK using a common budget case, splitting the SSD capacity in two to leverage the cheaper costs of SATA SSDs and using 5200MT/s RAM which is lower than AMD's recommended 6000MT/s. It also means that the GPU whilst solid, will be the bottleneck in your system when gaming above 1080p.

As a way to get onto the new AM5 platform, this is a good start and would be a nice project to upgrade over time as prices come down on better components.

CPU: AMD Ryzen 5 7600X; **Cooler:** Noctua NH-U12S; **Motherboard:** Gigabyte B650M Aorus Elite AX; **Graphics:** Gigabyte RTX 3060 Gaming OC 12G GDDR6; **Memory:** 32GB Corsair Vengeance RGB DDR5 5200MT/s C40; **Storage:** Samsung 500GB 970 Evo Plus M.2 NVMe SSD, Crucial BX500 1TB SATA SSD; **Power Supply:** Gigabyte GP-UD850GM 850W; **Case:** DeepCool Matrexx 55 Mesh.

PC BUILDER

Blueprints

Value- and performance-driven hypothetical builds

BUDGET

A perfect balance between price and peformance.

In our Intel budget machine, we see a welcome price drop on both our SSD and GPU this month. This frees up some budget to play with, so we thought we'd switch things up and modernise this rig. The first thing we changed was the motherboard – we've stuck with Asrock but swapped from a B660 chipset to a more powerful Z690 Phantom Gaming 4/D5. Not only does this upgrade our chipset but we also now have DDR5 support. These DDR5 sticks have dipped in price since their release and are now more affordable, so it's time to introduce them to our budget machine.

We swapped out our Corsair DDR4 3200MHz RAM for 16GB (2x 8GB) of Kingston Fury Beast @ 4800MHz. We also changed our previous Intel Core i5-12600 for the K-variant, a faster and stronger chip than before, so updating from DDR4 to DDR5 means the memory speed can increase from 3,200MHz to 4,800MHz which the 12600K supports. In terms of changes, the rest of this machine remains the same and with the fluctuating prices from last month's budget machine, all these changes and updates ended up costing us $221 more than the previous build.

For the AMD machine, we've kept things pretty much as they were. At the time of writing, we're waiting for next-gen budget GPUs to be released – this may see a shift in prices that will allow us to upgrade this build. If we can free up some budget, we may look at bringing in the newest budget AMD chip, the Ryzen 5 7600X. As that doesn't come with a stock cooler, we would have to bring in a CPU cooler to accommodate it and also an AM5 motherboard. That said, we've upgraded our mobo to an X570C chipset with the Asrock Steel Legend. We also swapped the MSI Radeon RX 6650 XT Mech 2X OC for a Gigabyte Radeon RX 6650 XT Eagle OC 8GB as the former was out of stock. Even with these upgrades, we are still $106 ahead compared to last month, thanks mostly to falling Radeon and Ryzen prices.

AMD INGREDIENTS

Part		Price
Case	Corsair 4000D Airflow	$140
PSU	550W Cooler Master MWE Gold 80+ Gold	$120
Mobo	Asrock X570 Steel Legend ATX AM4 Motherboard NEW	$245
CPU	AMD Ryzen 5 5600X	$259
GPU	Gigabyte Radeon RX 6650 XT Eagle OC 8GB NEW	$469
RAM	16GB (2x 8GB) PNY XLR8 Gaming Epic-X RGB @ 3200MHz	$149
SSD	500GB Corsair MP600 PCIe 4.0 M.2 SSD	$109
HDD	4TB Seagate SkyHawk Surveillance 7200	$129
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	$60
Total		$1,680

INTEL INGREDIENTS

Part		Price
Case	Corsair 4000D Airflow	$140
PSU	550W Asus ROG Strix 80+ Gold	$140
Mobo	Asrock Z690 Phantom Gaming 4/D5 ATX LGA1700 NEW	$269
CPU	Intel Core i5-12600K NEW	$429
GPU	Zotac GeForce RTX 3060 Gaming Twin Edge OC 12GB	$580
RAM	16GB (2 x 8GB) Kingston Fury Beast DDR5 @ 4800MHz NEW	$169
SSD	500GB MSI Spatium M450 PCIe 4.0 M.2 SSD	$79
HDD	4TB Seagate SkyHawk Surveillance 7200	$129
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	$60
Total		$1,995

"The change of motherboard and processor makes no difference to compatibility with the rest of the components."

MID-RANGE

A game-ready machine that can also handle demanding work.

As we ideally wanted to shift the new AMD Ryzen 5 7600X from this build into our budget AMD machine, we've taken it out of our mid-range machine and introduced the AMD Ryzen 7 7700X instead. Thankfully, the price of the Ryzen 5 7600X chip is now around the $400 mark, suiting the budget build more. This 7700X is a faster processor and contains two more cores and four more threads than the budget-oriented machines. We also changed the motherboard for our mid-range machine, bringing in the Asrock B650E PG Riptide WIFI ATX mobo. Previously, we had the Asus Prime B650M-A AX Micro ATX board here, so we decided to try and kill two birds with one stone by upgrading our chipset and also improving compatibility and future-proofing by going from Micro-ATX to ATX.

The change of motherboard and processor makes no difference to compatibility with the rest of the components. Our DDR5 Corsair RAM still works just as well with the new chip and board too. At the time of writing, we're still holding on for the latest AMD GPUs to hit the shelves so our Radeon RX 6800 XT won't be leaving this machine. The Asrock we used previously is now ultra scarce, so we've switched to the more common Asus RX 6800 TUF Gaming OC 16GB. Like the GPU, we keep the rest of the build the same.

As for the Intel mid-range machine, the Intel i5-13600K is capable of being able to sit alongside an RTX 4090 and produce some great benchmarking figures. That said, we can't put an RTX 4090 in the mid-range build now, can we? We'll have to pair it alongside Gigabyte's Gaming OC RTX 3070 Ti for now, as RTX 3080s are still too expensive to include in this section. The rest of our build contains a well-balanced bunch of components that don't need much further attention this time around.

AMD INGREDIENTS

Part		Price
Case	Nzxt H7 Flow	$219
PSU	750W Corsair RM750 80+ Gold	$189
Mobo	Asrock B650E PG Riptide WIFI ATX AM5 NEW	$429
CPU	AMD Ryzen 7 7700X NEW	$769
Cooler	Cooler Master Masterliquid ML240L RGB V2	$95
GPU	Asus Radeon RX 6800 TUF Gaming OC 16GB NEW	$949
RAM	32GB (2x 16GB) Corsair Vengeance DDR5 CL40 @ 5200MHz	$239
SSD	1TB Crucial P5 Plus NVME M.2 PCIe 4.0	$179
HDD	4TB Seagate SkyHawk Surveillance 7200	$129
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	$60
Total		$3,257

INTEL INGREDIENTS

Part		Price
Case	Nzxt H7 Flow	$219
PSU	750W Gigabyte P750GM 80+ Gold	$189
Mobo	MSI Pro Z690-A ATX LGA 1700	$279
CPU	Intel Core i5-13600K	$539
Cooler	Cooler Master Masterliquid ML240L RGB V2	$95
GPU	Gigabyte GeForce RTX 3070 Ti Gaming OC 8GB	$1,099
RAM	32GB (2x 16GB) Corsair Vengeance DDR5 CL40 @ 5200MHz	$239
SSD	1TB Crucial P5 Plus NVME M.2 PCIe 4.0	$179
HDD	4TB Seagate SkyHawk Surveillance 7200	$129
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	$60
Total		$3,027

"With an RTX 4090, it is hard not to get excited about this Turbo build. We've been lucky enough to test two different RTX 4090 cards and, boy, can this card perform."

TURBO

The maximum PC.

We are still waiting for the latest AMD GPUs to be widely available, so will start with the Intel build. With an RTX 4090, it is hard not to get excited about this Turbo build. We've been lucky enough to test two different RTX 4090 cards and, boy, can this card perform. It isn't without its building challenges though.

Our Asus ROG Strix GeForce RTX 4090 OC 24GB in last month's review needed three and a half slots to fit in. To pre-empt any PSU issues, we have selected a PSU up to the task and then some and with at least 1,000W. Specifically, Thermaltake's ToughPower GF3 1200 80+ Gold.

We also swapped out the Asus GeForce RTX 4090 TUF and upped it to the beastly Asus ROG Strix RTX4090 OC Edition which we reviewed in issue 514. It's simply the king and the Turbo build deserves a treat like this. We will be swapping out a Z690 with a Gigabyte Z790 Aorus Elite AX ATX LGA1700 mobo to keep that as up-to-date as possible.

On the AMD build, we spruced up the Turbo machine last month, adding the AMD Ryzen 9 7900X. We also gave it the best AMD chipset with the Asrock X670E PG Lightning ATX motherboard – and both of these aren't going anywhere just yet. The Radeon RX 6950 XT GPU, the best we can include in this rig, is far cheaper than the RTX 4090 in the opposing camp. It remains the MSI Gaming X Trio Radeon RX 6950 XT.

We stuck with our trusty 6TB WD Blue 5400 HDD for the Turbo and mid-range machines and are also using 1TB of SN850X on both Turbo PCs. Another component shared across these two builds is the RAM, and we've stuck with 64GB of Corsair's Vengeance DDR5 @ 5200MHz. With the various price ups and downs, the overall price of the AMD machine fell by a stupendous $10, though it may rise when we add the new AMD GPUs to the mix. There's a huge difference in price between the two Turbo machines, but that's down to the crazy RTX 4090 prices.

AMD INGREDIENTS

Part		Price
Case	Phanteks Enthoo Pro 2 Tempered Glass	$220
PSU	Thermaltake ToughPower GF3 1200 80+ Gold NEW	$399
Mobo	Asrock X670E PG Lightning ATX AM5	$499
CPU	AMD Ryzen 9 7900X	$769
Cooler	Cooler Master MasterLiquid ML360R RGB 66.7 CFM 360mm	$149
GPU	MSI Radeon RX 6950 XT Gaming X Trio 16G	$1,899
RAM	64GB (2x 32GB) Corsair Vengeance DDR5 CL40 @ 5200MHz	$569
SSD	1TB WD Black SN850X M.2 PCIe 4.0	$249
HDD	6TB WD Blue 5400 HDD	$189
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	$60
Total		$5,002

INTEL INGREDIENTS

Part		Price
Case	Phanteks Enthoo Pro 2 Tempered Glass	$220
PSU	Thermaltake ToughPower GF3 1200 80+ Gold NEW	$399
Mobo	Gigabyte Z790 Aorus Elite AX DDR5 LGA 1700 NEW	$539
CPU	Intel Core i9-13900K	$1,099
Cooler	Nzxt Kraken X73 73.11 CFM 360mm	$279
GPU	Asus ROG Strix GeForce RTX 4090 OC 24GB NEW	$3,799
RAM	64GB (2x 32GB) Corsair Vengeance DDR5 CL40 @ 5200MHz	$569
SSD	1TB WD Black SN850X M.2 PCIe 4.0	$249
HDD	6TB WD Blue 5400 HDD	$189
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	$60
Total		$7,402

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QUICK TIPS

The problem solvers

The APC team field problems across the spectrum of devices and software. Learn a new trick or fix you can use.

Drive stopped working

I have a 3.5-inch hard drive that has been attached to my PC via an external SATA adapter for over a year now. Recently, I booted into Windows only for the computer to hang.

I eventually traced the problem to this drive – powering it off 'fixed' the problem but introduced a new one. Now, when I power the drive back on, its drive letter appears in File Explorer but shows no drive space information.

If I double-click the drive to try and open it, I eventually get a 'Location not available: The file or directory is corrupted and unreadable' message. If I open Disk Management, the drive shows up as healthy, but as a RAW partition. Does this mean the drive is toast?

John Arteaga

> "I fancied trying out some of the new features in Windows 11 22H2 but was disappointed to find many, such as File Explorer tabs, weren't available."

APC responds: It sounds like the drive's partition header has become corrupt somehow – John mentioned that the drive was running hot when it malfunctioned, but as drives routinely run 35-50°C when under load this shouldn't necessarily indicate there's a problem.

We instructed John to download and extract the 64-bit GUI version of the free portable DMDE data recovery tool (**https://dmde.com/**). Once that's installed, launch dmde.exe and select a drive from 'Physical Devices' from the 'Select Disk/Task' page and click OK.

DMDE will list all volumes it can see, including those not currently visible to Windows. In John's case, his NTFS partition was displayed. Double-clicking this opened a new tab, revealing empty $MetaData and $Root folders, plus an [All Found/Virtual FS] entry that he needed to click. This provides an option to build a read-only virtual file system. Untick 'include deleted' and leave 'Pure FS reconstruction' selected before clicking OK.

John received an 'Error reading MFT#16-38' message, indicating where the corruption lay – clicking OK provided a virtual reconstruction of the underlying NTFS partition, complete with a list of all missing files and folders.

The free version of DMDE allows you to recover up to 4,000 files per session from selected folders – select each folder in turn, then press Ctrl-U. Follow the prompts to select all the files within that folder, then choose where to recover them to before clicking OK.

If you'd like to select everything on the drive and recover it in one go, then purchase a license. DMDE Express costs just US$20 for a one-year license, or you can purchase a Standard lifetime license for US$48.

Once your files have been recovered, you can then simply create a new NTFS partition using Disk Management, transfer the files back if required and continue to use the drive as before. However, before pressing the drive back into service, use a tool like HDDScan (**https://hddscan.com/**) to make sure it isn't showing any signs of imminent failure.

Launch apps together

After following your advice last issue and adding yet more apps, MetaX and RenameMyTVSeries, to my media-editing toolkit, I've realised it's now a real chore having to open them one by one when I come to use them. I've no desire to have them all start with Windows as I use them once a week, so is there another way I can automate the process of launching them with a single click?

Marco Eberhardt

APC responds: APC has just the tool for this – a free portable program called Splat. Go to **www.dcmembers.com/skwire/download/splat/** to download and run it. First, click the 'Create new profile' button underneath the File menu and give your profile a suitable name. Click OK, then right-click the profile and choose 'Edit launch hotkey' to assign it a keyboard shortcut.

Press the [Insert] key or choose 'Edit > Insert Entry' to create your first action. Leave 'Run (if not running)' selected and click the '...' button next to the file icon to select the first program to launch. Add /user:Administrator to the Arguments box if you need to launch it with administrator privileges. If you don't want to clutter your desktop with another open window, set the Launch state to Minimised. Click Save when done.

Repeat the process for any other files or programs you wish to launch. Actions are executed in the order they are created – to introduce a delay after one is executed, add an action using the 'Wait/delay' action to set the pause time. Test your action at any time by pressing the shortcut combination key you created in step 1. Drag and drop actions to change their running order, and examine other available actions too, such as closing programs or starting services.

Disk errors in Linux

I recently added a generic ASM1062 PCI-E SATA card to my Ubuntu-powered server to add an extra drive, but since doing so, I keep getting errors that are linked to the 3TB drive (dev/sdc1) attached to the PCI-E card.

The errors aren't consistent – sometimes they appear on boot and at others, they pop up later. I suspect they're linked to attempts to write to the drive, although the data appears to be on there. None of my other drives (all 6TB) are affected. Is this likely to be a faulty card?

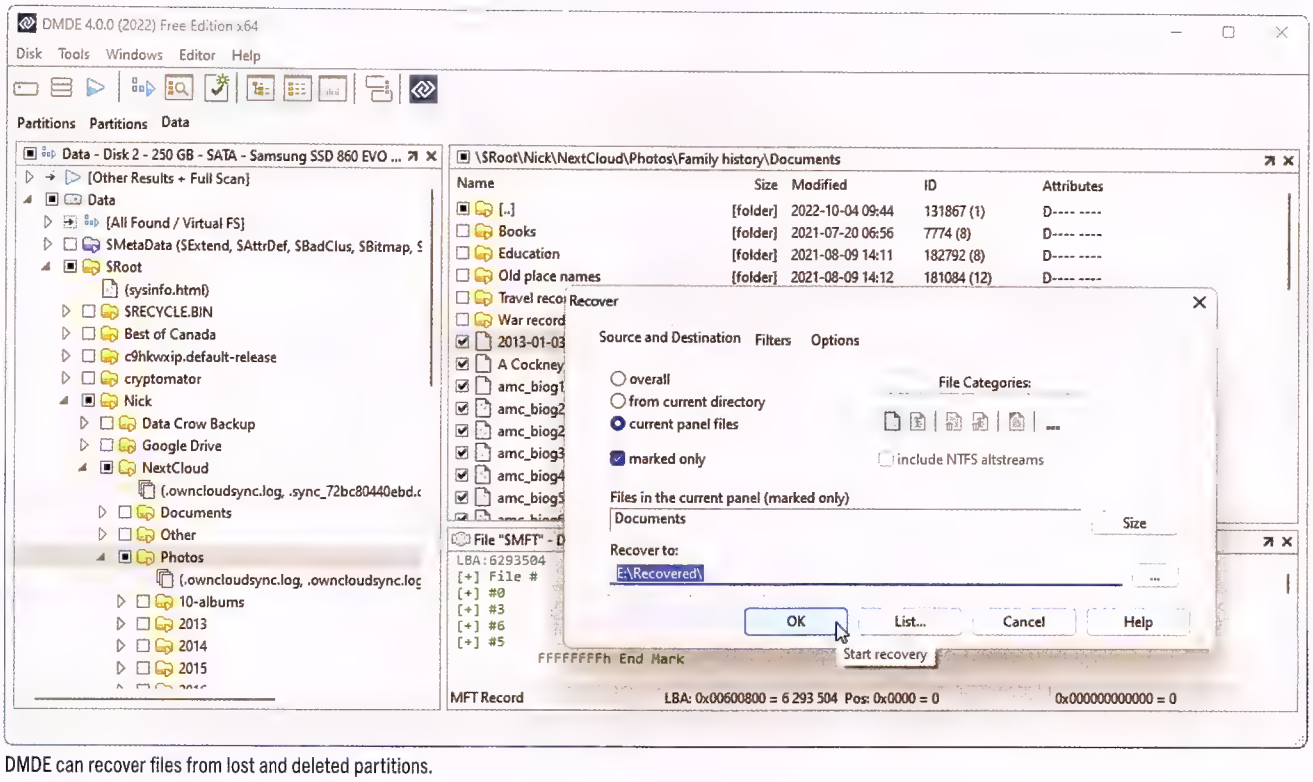
Harry A Ellis

APC responds: Harry was getting two different sets of errors. The most critical were a slew of read/write errors, indicating a problem with the drive. They were accompanied by the occasional WRITE FPDMA QUEUED and related ATA bus errors.

We suspect the two errors are related. Harry had already tried two fixes: replacing the SATA cable and changing the port into which he plugged the drive on the two-port PCI-E card, all to no avail. Our priority was to get a SMART reading on the affected drive to see if imminent drive failure might be the underlying cause. This is done in an Ubuntu Server environment with the help of a package called smartmontools:

```
sudo apt install smartmontools
```

Once installed, use the smartctl tool to discover a drive's SMART status:



DMDE can recover files from lost and deleted partitions.

sudo smartctl --all /dev/sdc

This command should output a comprehensive SMART readout, but Harry reported another error message: "A mandatory SMART command failed: exiting. To continue, add one or more '-T permissive' options". We ran smartctl on the other drives that were all connected directly to the motherboard's four onboard ports. Unsurprisingly, these yielded no such errors and delivered the comprehensive readouts we were expecting.

Given the problematic drive was connected to the PCI-E card, we asked Harry to swap connections with another of his internal drives after powering down his server. This can be done by swapping cable connections between drives or, in Harry's case, making use of his server's hot-swappable drive bays. After rebooting, he got a full SMART report from both the troublesome 3TB drive and the 6TB drive he'd swapped it with.

Miraculously, the write errors also ceased. We asked Harry to check the Logs for warnings as well as errors – sure enough, the 3TB drive required a disk check using e2fsk. This can't be done from within Ubuntu Server; instead, boot into a live Linux environment using a bootable Ubuntu flash drive. Once at the Ubuntu desktop, launch GParted to verify the drives are assigned the same file (/dev/sd?) as they are in Ubuntu Server. Once done, open a Terminal window and issue the following command (/dev/sdd1 was the new location of his 3TB drive):

sudo fsck -f /dev/sdd1

The check was completed with no errors, and Harry rebooted into the Ubuntu Server proper. It seemed the 3TB's write error problems were fixed but the original ATA bus errors showed up again. A deep dive online revealed these could be due to a faulty SATA cable, lack of power, or the controller.

Having eliminated the cables, we examined Harry's PSU, an InWin 265W PSU (**www.in-win.com/en/pc-power-supply/ip-s-series-au/USA**). A closer examination of both that and his installed drives revealed there should be plenty of power to spare across both +12V and +5V rails. Harry also confirmed that all power cables were connected.

This left us pointing firmly at the controller. While Harry could try replacing the PCI-E card with a known brand, such as Startech's ASM1061-based card, there's no guarantee it will work. We came across a reference to users reporting the errors occurring with drives plugged into the second SATA port on the controller, so we asked Harry to switch cables back to port 1, which seemed to fix the problem.

If it comes back, Harry may want to disable NCQ (Native Command Queuing), though this may come at the expense of performance.

Early access to features

I fancied trying out some of the new features in Windows 11 22H2 but was disappointed to find many, such as File Explorer tabs, weren't available. I've read that Microsoft often splits its releases into A/B groups, with some getting certain features first. How can I get myself into the right group for accessing the tools I want to preview as opposed to what Microsoft thinks I should?

Kenny Upton

APC responds: While the A/B feature is good for testing purposes, it can be frustrating missing the cut if you upgraded for one specific feature. If you're willing to take risks, take a drive image using a tool like Macrium Reflect Free (**www.macrium.com/reflectfree.aspx**) then you can bypass Microsoft's decision-making measures with the help of a free tool called ViVeTool-GUI.

Go to **https://github.com/PeterStrick/ViVeTool-GUI/releases** to download the latest version as a portable tool or installer. Once installed or extracted, open the tool (ViVeTool_GUI.exe) and if prompted, click 'More info' followed by Run anyway.

Once administrator access is granted, it should scan for the latest available set of features. After this seemingly inexhaustible list loads, identify the feature you want to switch on, then enter its name into the Search box.

Enabling tabs in File Explorer, for example, is handled by a feature called TIFE (feature ID 37634385), while enabling the Task Manager entry when right-clicking the Taskbar can be found under Servicing_TaskbarTaskManager (feature ID 36860984).

Once located, select the feature, click the Perform Action button and choose 'Activate feature', then reboot to see if the feature is now available. ■

© DMDE

WINDOWS

Under the hood of Windows 11 22H2

Nick Peers has the update guide to go with the new Windows version.

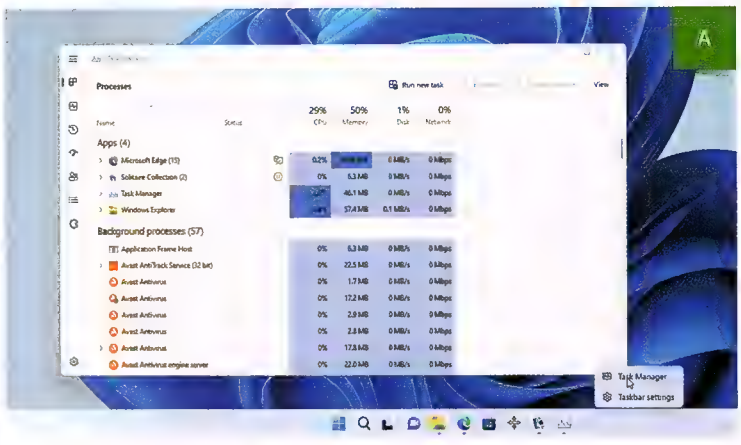
YOU'LL NEED
Windows 11 and the 22H2 update
If you've not yet received it, check the box for troubleshooting tips.

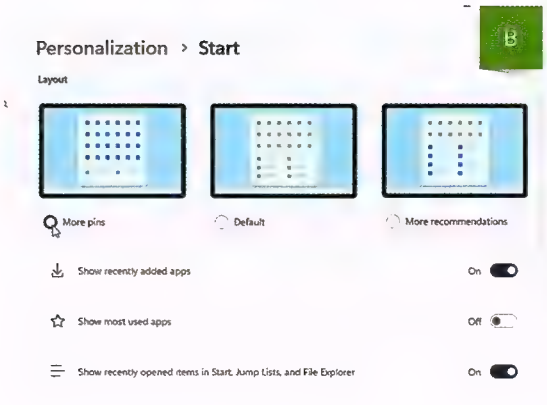
The first major update to Windows 11, 22H2, is here, and with it, a whole new way of delivering future updates. In this month's tutorial, we're going to take you on a tour of all its major new features and a few minor ones, too. Crucially, though, we're not going to simply provide you with a list of what's new and improved and then leave you to find it all yourself. No, we'll show you exactly where to find each new feature and reveal how to make the most of it.

You'll discover how to make the best use of tabs in File Explorer, add live captions from any audio source (including your own microphone), plus discover some gaming enhancements to boost performance and make games easier to access. Focus Assist gets an overhaul to help improve your productivity by removing unwanted distractions for short bursts, and Task Manager finally gets an overdue facelift to fit in with the rest of Windows 11's redesign.

"Let's start our look at Windows 11 22H2 by acknowledging the ongoing process of streamlining and modernizing the Windows user interface"

And all that's before we look at the incremental improvements the update brings to key features ranging from Snap Assist to the Start menu. Enough showboating, it's time to get down and dirty with Windows 11 22H2.





Shell improvements

Let's start our look at Windows 11 22H2 by acknowledging the ongoing process of streamlining and modernising the Windows user interface – a seemingly endless process dating back to the launch of Windows 10. Press Alt-Win-K to reveal a new control for muting the mic during calls in supported apps in Teams. The redesigned flyout, which pops up above the taskbar, extends to other hardware controls such as volume and brightness – if your keyboard supports these, try them now.

The biggest beneficiary of this ongoing facelift is Task Manager **[Image A]**. If Task Manager isn't yet an option when right-clicking the taskbar, press Ctrl-Alt-Del and select 'Task Manager' to open it to the Process section. A series of buttons down the left replaces the tabs found on the old version – reveal their names via the ≡ button if the icons aren't self-explanatory.

You will also see some shortcut buttons within each section– 'Run new task' is found on all sections, while others are context-sensitive (for example, Enable and Disable options for selected apps under Startup apps). Also, look out for the Settings button, where you can choose your default start page among other things.

These design tweaks continue elsewhere throughout Windows, too – look out for subtle changes to icon designs in context menus or new folder preview icons when browsing user folders to help identify content inside. One specific example can be seen by right-clicking a file and choosing 'Open with > Choose another app'.

Start menu

We're still not convinced by Windows 11's lackluster Start menu, but the 22H2 update does introduce a couple of minor improvements. Ironically, these mainly restore features stripped from the Windows 10 Start menu, such as the ability to create app folders inside which related items can be nested, for example, plus the ability to adjust the relative sizes of the pinned and recommended app sections.

To change the latter, right-click on any blank space on the Start menu and choose 'Start settings' to be whisked off to Settings > Personalisation > Start. Here you'll see three thumbnails – the Default setting gives both pins and recommendations equal space, but you can easily switch them to give either one or the other prominence **[Image B]**.

When it comes to grouping apps into folders, simply drag one app icon within the Pinned

section onto another to group them together, then click the folder followed by 'Edit Name' to rename it. You can drag other apps into this folder in the same way or open the folder and drag an app icon out of it to remove it.

Speaking of apps, you'll notice some name changes under All Apps: Terminal (instead of Windows Terminal), Windows Media Player Legacy, and Accessibility instead of 'Windows Easy of Access'. Similarly, right-clicking the Start button reveals 'Apps & Features' is now labeled 'Installed apps'.

One other change is that you can now quickly change the way you sign into Windows by right-clicking the power button on the Start menu, where you'll find a new 'Sign-in options' shortcut to the relevant area (Accounts > Sign-in options) of Settings.

Taskbar improvements

The taskbar also regains some useful functionality. By now, you should hopefully see 'Task Manager' appear when right-clicking it as a useful shortcut. A new feature sees an overflow (...) button appear if you've filled up the taskbar with icons (pinned or otherwise). Click this to reveal all hidden items. Adding pinned items to the taskbar from the Start menu has also gotten easier – simply expand 'All apps' and drag your chosen shortcut onto the taskbar to pin it as a link.

Another restored feature lets you drag a file onto an open app's icon on the taskbar. Wait for the app window to pop up and then simply drag the file where it needs to go to open it in that application.

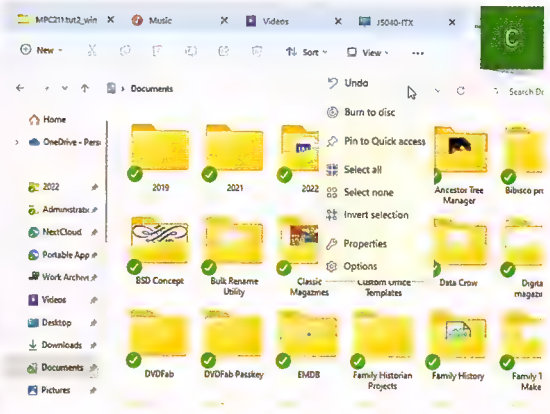
Here's a handy shortcut. Want to quickly change the system volume? Place the mouse pointer over the taskbar notification area's quick settings button (the one combining network, audio, and, if applicable, power icons), and you can then use the scroll wheel to increase (scroll up) or decrease (scroll down) the volume as required.

There are also a few minor changes when you click the button to open the Quick Settings flyout. You'll see that the Bluetooth button gains an expanded (>) button – clicking this allows you to access Bluetooth-connected devices and pair with others, just as the Wi-Fi button allows you to switch networks. One feature conspicuous by its absence from Quick Settings is the Focus assist button, but more on that shortly.

File Explorer tabs

Obviously, the huge new feature in File Explorer is support for tabs **[Image C]**. At last, no more cluttering your desktop with two or more separate windows; instead, use the tab bar at the top of the File Explorer window to group related folders together. Click + or press Ctrl-T to open a new tab, then simply browse to where you want it to point. From here, you can drag files and folders onto a tab to bring that tab into focus before dropping the file where you want it to go (don't forget the usual rules surrounding moving and copying – hold Ctrl to force the file to copy or Shift to force it to move if you're not sure).

You'll be pleased to learn that tabs work in the same way as in Edge: you can click and drag tabs to rearrange them, close the tab via the 'x' button, or right-click a tab for more options, including



closing all other tabs or simply those to the right of the currently selected tab.

File Explorer navigation

File Explorer's other major change can be seen in the Navigation pane on the left. It has been reorganized into three primary sections: Home and OneDrive sit at the top, pinned and frequently accessed folders are located in the middle section, and beneath this are other views: My PC, external drives, your network, other linked cloud folders (such as Nextcloud), and so on.

The Home folder is basically a revamp of the old Quick Access view. It comprises three collapsible sections: Quick access, Favourites, and Recent. These are all largely self-explanatory – Quick Access mirrors what's shown in the left-hand navigation pane, while Favorites is a new section where you can pin your frequently accessed files. Simply right-click a file and choose 'Add to Favorites' to pin it. Right-click the Home folder in the navigation pane and you can also pin it to your taskbar or Start menu for easy access.

WHITHER 22H2?

By now, your PC should have offered you the latest feature update, but if for any reason Windows Update still hasn't made it available, then you need to determine whether there's a setting or device on your PC that might be blocking the update.

Start by searching for PowerShell, then click the 'Run as Administrator' option that appears beneath it. Now enter the following command:

Install-Module FU.WhyAmIBlocked -Scope CurrentUser

You'll be prompted to install the NuGet repository, press Y, and hit Enter twice when prompted. Once done, type the following command to adjust your PC's script policy:

Set-ExecutionPolicy -ExecutionPolicy Unrestricted

Again, press Y when prompted. Now type the following two commands:

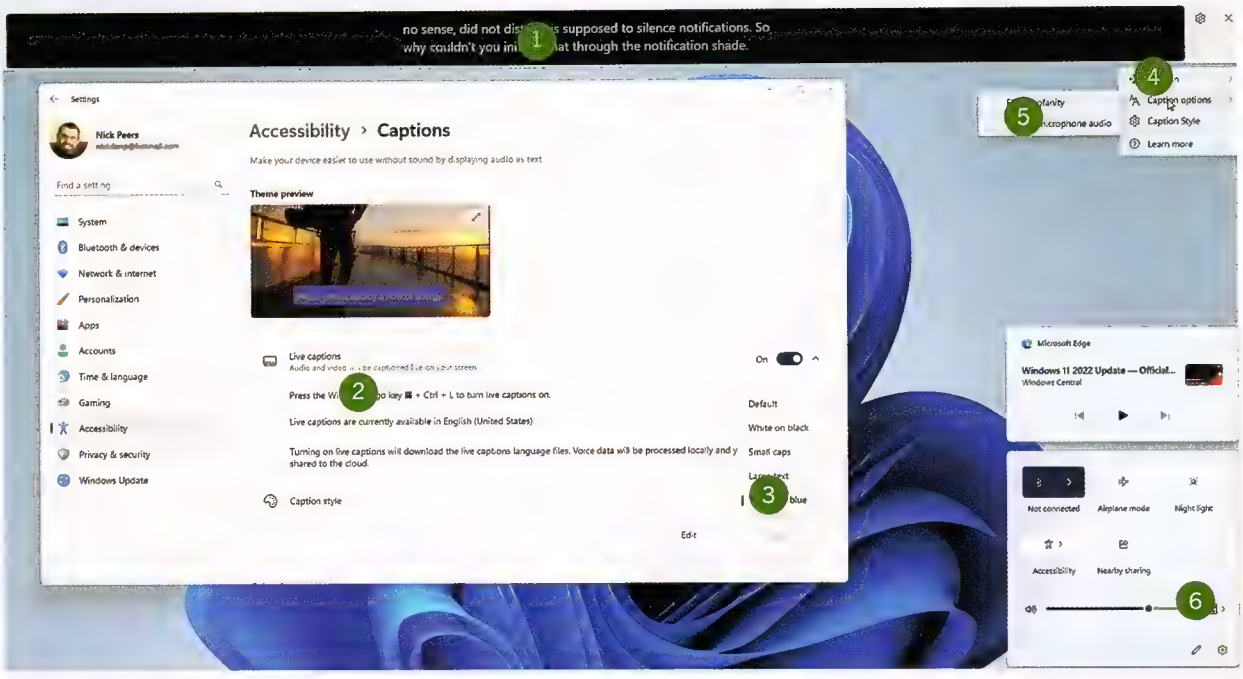
Import-Module FU.WhyAmIBlocked

Get-FUBlocks

Once the scan is complete, you'll hopefully be told no blocks exist.

If this is the case, attempt to install the 22H2 update using the Windows Installation Assistant (www.microsoft.com/software-download/windows11) – we would recommend running the installer with administrative privileges.

If there are blocks, review the text file generated and Google to see what remedies there may be. For example, temporarily disabling Windows Hello as a form of logon or removing certain printer drivers.



LIVE CAPTIONS

1. LIVE CAPTIONS PANEL

By default, the Live Captions panel sits at the top of the screen. The first time you open it, you'll be prompted to download the processing software required.

2. ENABLE LIVE CAPTIONS

If you prefer, you can toggle Live Captions on or off via Settings > Accessibility > Captions, but it's far easier to learn its keyboard shortcut: Ctrl -Win-L.

3. CAPTION STYLE

Don't like the caption's font, style, or colour? Then there's a handy dropdown menu offering you five quickfire choices; alternatively, click Edit to set up your own style from scratch.

4. CAPTION POSITION

Choose Settings > Position should you wish to either place your captions at the bottom of the screen or have them in a floating semi-translucent window that sits on top of other windows.

5. CAPTION OPTIONS

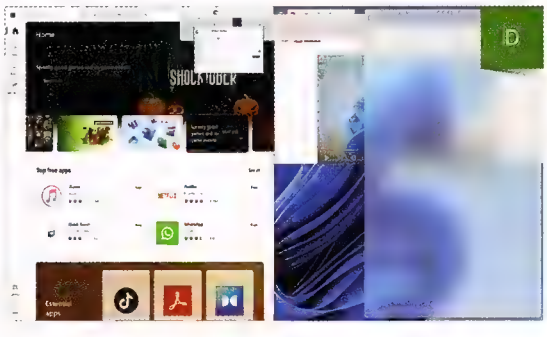
Make your captions family-friendly by enabling the profanity filter. If you are presenting to others, choose 'Include microphone audio' to provide real-time closed captions as you speak.

6. SWITCH SOUND DEVICE

If you have multiple sound outputs on your system, open the Quick Edit panel via the taskbar notification area to switch outputs via this button if required.

One final tip: when browsing the Recent list in Home, look for the Filter button in File Explorer's taskbar: click this to show only those file types you're interested in.

Elsewhere, you'll see subtle changes to some of the pop-up menus – right-click This PC to reveal more options for adding network locations, for example, while an additional 'Connect to a media server' option appears when clicking the '...' menu in This PC view. Also, note the redesigned icons we mentioned earlier when displaying a folder's contents as large or medium icons.



A new Focus

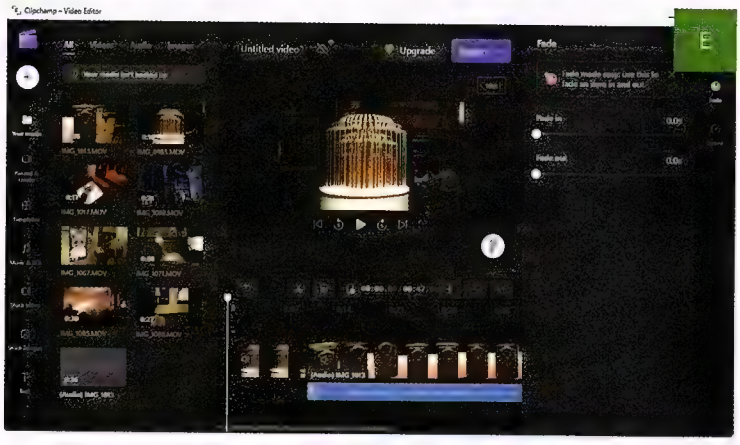
Another tool undergoing a name change is Focus (formerly Focus Assist). This isn't just a cosmetic change, it has been moved from Quick Settings to reside under the pop-up calendar that appears underneath Notifications when you click the date and time in the taskbar notification area. Beneath the calendar, you'll see a button for enabling Focus along with controls for determining how long you want it to run.

There are also changes to how Focus is configured. Navigate to Settings > System and you'll find the Focus section concentrates on providing universal options: the session duration, whether the clock app shows a timer and a 'do not disturb' setting, alongside options for hiding flashing and badges on taskbar apps.

Beneath this is a Notifications shortcut. This reveals where the automatic rules have migrated to, namely System > Notifications. Here, you can configure 'do not disturb' and choose priority notifications and other apps that you're happy to provide updates during a session.

Gaming improvements

Windows 11 is keen to enhance its gaming credentials, and the 22H2 upgrade delivers some welcome improvements. If you have an Xbox controller or



similar, pressing the Xbox button on your controller pops up a new Controller bar providing a convenient shortcut to access both game launchers and recently played games.

Gamers can now enjoy DirectX 10/11 display latency improvements when playing games in windowed mode as well as full-screen. Enable this feature via 'Settings > System> Display > Graphics > Change default graphics settings'. Other features extended to windowed mode include support for automatic HDR and variable refresh rate (VRR). Speaking of HDR, there's a new HDR Calibration app to help boost the colour accuracy and consistency of your HDR-capable display.

If you've set up a webcam for video conferencing or gaming, you'll be pleased to learn that the 22H2 update rolls out new audio and video configuration options via 'Settings > Bluetooth & devices > Cameras'. If your camera supports it, look out for a new Camera Effects section, offering such features as background blur, automatic framing, eye contact, and a separate voice focus option, which attempts to filter out background noise.

Windows management

Windows 11 delivers further improvements in two key areas of application and window management: Snap Assist and Task View. Start dragging a window and you'll see the bottom of the Snap Assist window peek out from the top of the screen. Drag your window here to access six different layout types supporting up to four windows.

Simply drag your window into one of the windows **[Image D]** and a blurred preview of where the window will appear on-screen is shown. Let the mouse button go and the selected window will be resized and shaped accordingly. You'll see the remaining applications appear in one of the other windows – click one to place it here, then move on to the next to create a snap group, or simply click inside the main application to leave all other windows as they currently stand.

Snap groups come into play when switching between application windows using the Win-Tab key or Task View button on the taskbar. In addition to individual application windows, you'll now be given an opportunity to switch to a different snap group too. Another related change is that the Alt-Tab switcher now displays each app in its own windowed interface.

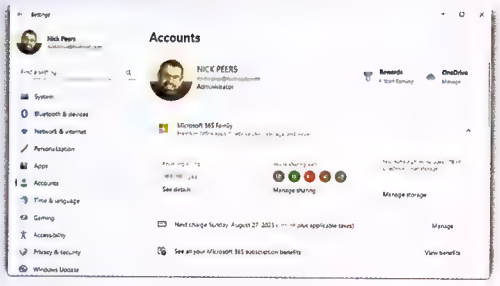
And there's more...

Those changes keep on coming. A feature slowly rolling out from the October 'Moments' update is Suggested Actions. When you copy a date, time, or phone number, Windows will pop up a suggested actions panel with relevant options, such as opening certain apps, calling the number, or creating a calendar event from a copied date.

Windows 11 22H2 also bundles two new apps: ClipChamp for video editing **[Image E]** and a new version of Sound Recorder titled Voice Recorder. Other bundled apps also get updates, but these require installing through the store – they include Photos, which adds support for directly uploading photos to OneDrive and a new curated Memories feature, plus Microsoft Family Safety (which drops the 'Safety' from its name).

Look out too for the new Smart App Control tool, accessible through the 'App & browser control' section of Windows Security. Sadly, this feature is only available via clean installs of Windows 11, but if enabled, could help you avoid malicious and potentially unwanted apps through careful monitoring of their behavior.

Last, but not least, is Live Captions. These enable you to generate closed captions on the fly for any audio (or video) file currently playing. They're currently restricted to English-language audio, but all processing is done locally, so there are no security ramifications involving sending your files to the cloud. You can even use Live Captions to generate captions when speaking into your mic – see the annotation for more details of what it offers. ■



FEATURE PACKS

The Windows 11 22H2 update opens with a major cultural shift. You'll have noticed this if, after first updating, you discovered the long-awaited tabs in File Explorer were missing because Microsoft held the feature back. That's the bad news; the good news is you won't have to wait 12 months for it to finally appear in 23H2. That's because Microsoft has unveiled a new way of rolling out feature updates.

It was quick to demonstrate this new approach when it announced the first of these so-called 'Moments' on 18th October. Not only were tabs finally implemented, but additional improvements also saw the return of the 'Task Manager' option to the Taskbar's context menu as well as additions to the Accounts section under Settings, like the ability to review and manage your Microsoft 365 account.

Annoyingly, these features may not appear all at once; for example, support for tabs and pinning files in File Explorer appeared in the 18th October out-of-band update, while the new Accounts feature turned up a week later in the 25th October update. We saw the Accounts feature appear first after finally updating to 22H2 on 30th October – the File Explorer improvements rolled up the following day after installing the October Cumulative Update.

WINDOWS

How to update your GPU drivers

Driver guide

YOU'LL NEED
An Nvidia, AMD, or Intel GPU Display Driver Uninstaller.

Most people typically buy and install a new graphics card and leave it alone. Perhaps years may pass before it's again time for a GPU upgrade. In the interim, though, there will inevitably be plenty of driver updates made available. That's especially true when a new GPU architecture that comes along, such as Nvidia's Ada Lovelace, Intel's Arc Alchemist, or AMD's RDNA 3. – Jarred Walton

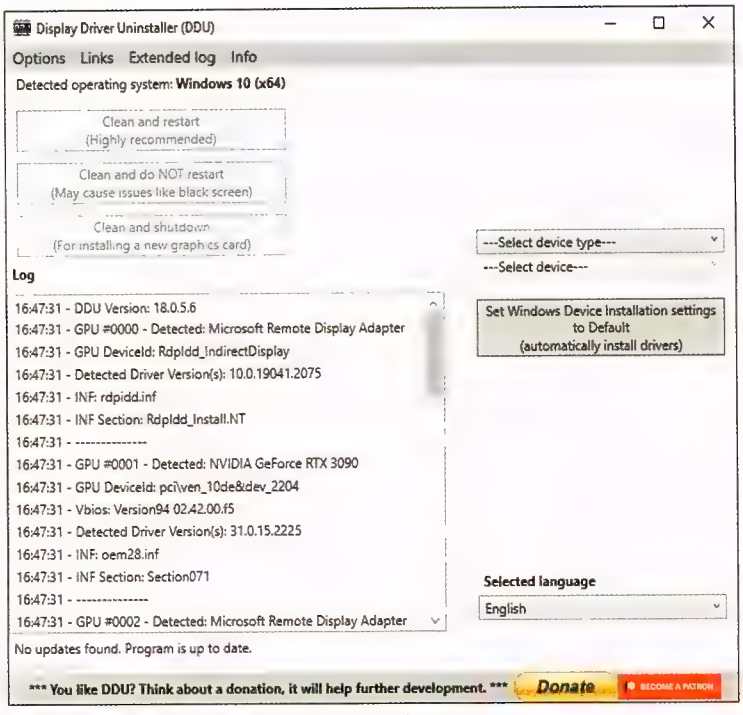
All going swimmingly?

You might think updating to new drivers is a relatively simple and painless process, and on the surface, it is. All three major GPU manufacturers provide the option to uninstall their respective drivers via the Control Panel. Furthermore, you can elect to do a 'clean install' when updating to the latest release. Most of the time, things will go swimmingly, with your PC and OS none the worse for wear.

"Occasionally, things don't go so well. Sometimes you end up with corrupted drivers that won't uninstall properly, or they uninstall but leave behind undesired cruft."

But occasionally, things don't go so well. Sometimes you end up with corrupted drivers that won't uninstall properly, or they uninstall but leave behind undesired cruft. We've experienced situations where performance inexplicably drops, and the only way to ensure your drivers are working properly is to clean them.

It's also a good idea to execute a thorough cleaning of old GPU drivers if you happen to switch from an Nvidia GPU to an AMD GPU – or an Intel Arc GPU. For that matter, even if you just upgrade from an old Nvidia card to a new Nvidia card, wiping out any remnants of the older card is a good idea. Technically, you don't have to do this, but there's also no reason to keep the old drivers unless you're trying to concurrently run mixed GPUs on one system. [Shudder!]


Display Driver Uninstaller (DDU)
Options Links Extended log Info
Detected operating system: Windows 10 (x64)
Clean and restart
(Highly recommended)
Clean and do NOT restart
(May cause issues like black screen)
Clean and shutdown
(For installing a new graphics card)
---Select device type---
---Select device---
Log
16:47:31 - DDU Version: 18.0.5.6
16:47:31 - GPU #0000 - Detected: Microsoft Remote Display Adapter
16:47:31 - GPU DeviceId: RdpIdd_IndirectDisplay
16:47:31 - Detected Driver Version(s): 10.0.19041.2075
16:47:31 - INF: rdpidd.inf
16:47:31 - INF Section: RdpIdd_Install.NT
16:47:31 - ----------
16:47:31 - GPU #0001 - Detected: NVIDIA GeForce RTX 3090
16:47:31 - GPU DeviceId: pci\ven_10de&dev_2204
16:47:31 - Vbios: Version94 02.42.00.f5
16:47:31 - Detected Driver Version(s): 31.0.15.2225
16:47:31 - INF: oem28.inf
16:47:31 - INF Section: Section071
16:47:31 - ----------
16:47:31 - GPU #0002 - Detected: Microsoft Remote Display Adapter
Set Windows Device Installation settings to Default
(automatically install drivers)
Selected language
English
No updates found. Program is up to date.
*** You like DDU? Think about a donation, it will help further development. ***
Donate
BECOME A PATRON

Display Driver Uninstaller doesn't bother with fancy logos or animations. It's simple, clean, and it gets the job done.

Time for a deep clean

So how do you go about doing a deep cleaning of your graphics card drivers? The manual process would consist of scouring your drive and registry for any remnants. You'd probably miss some stuff, and there's certainly a chance you'd delete something you shouldn't.

Thankfully, a handy utility called Display Driver Uninstaller will do all the dirty work for you. It's been around a few years now and gets routinely updated. It also has support for removing audio drivers as well as graphics. The important thing is that it's programmed with all the knowledge of where AMD, Intel, and Nvidia store the various registry settings and files, so it knows exactly where to look at what to delete.

Perhaps the most difficult part of the process is getting DDU in the first place. The developer always has the latest version at **www.wagnardsoft.com**, but there are some advertising links and other buttons that can get in the way. Just look for the latest version (V18.0.5.6 at the time of writing), click that for a page that shows the changelog, then hit the 'Click here for download and support' link. Finally, on that page you should see a link that says '***Official Download Here***' and that will get you the necessary self-extracting Zip file.

Unpack that to whatever location you want, then open the 'Display Driver Uninstaller.exe' application. It will warn you about not being in Windows Safe Mode, a holdover from the pre-Windows 10 era. Don't worry about that; the program works fine without being in Safe Mode. (Reboot and run it a second time if you're concerned about it missing something).

Take the nuclear option

The settings are mostly self-explanatory, but it's worth taking a moment to configure the options. We don't want

Windows automatically downloading new display drivers, so we check the appropriate box. We also turn off the automatic system restore point creation and the advertisements. Then we tell it to delete all the bits and pieces that come with modern graphics drivers.

Beyond that, all you need to do is select the appropriate device type – we only use it for GPUs, but you can try the audio option if you want – and then choose your GPU vendor. The app is smart enough to detect your currently active graphics driver and will default to that, but if this is the first time you've used DDU it won't hurt to wipe out any potential remnants from the other graphics vendors.

As an example, if we're using an Nvidia card, we start by selecting AMD and hitting the 'Clean and do NOT restart' button. After a minute or so, the program finishes the cleaning and asks if we want to exit. We choose 'No', then select Intel, again without restarting. Only after those are both gone do we move on to wiping out the currently active Nvidia drivers. This time, we choose 'Clean and restart' – or if planning on installing a new graphics card, opt for 'Clean and shutdown'. All three GPU vendors get nuked into oblivion. It's the only way to be sure.

Problems wiped out

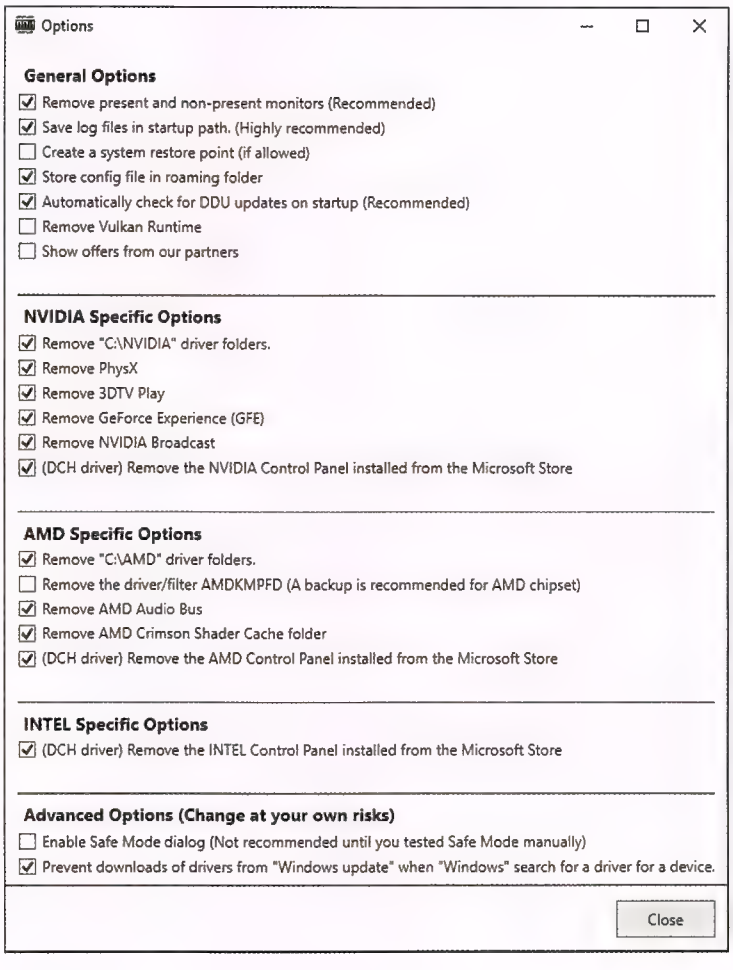
At this point, the PC should be good and ready to welcome whatever graphics card we might want to install for testing. You're probably not doing that, but following the same process still has benefits. We don't have a lot of hard data, but anecdotally, if you've never used DDU and have only relied on the GPU company uninstallers, there's a chance you'll see improved performance on whatever card you're currently using. Even if you don't, there's no harm in getting rid of old files you no longer need. We know someone who ran DDU and freed up over 20GB of drive space that was occupied by old driver installation files.

The bottom line is that our process for testing different graphics cards has benefited greatly from DDU. It only takes a few minutes to run, at which point, we can be reasonably certain any problems we might experience aren't due to driver cruft. For example, when AMD launched the RX 6700 XT, we had problems and informed AMD the card wasn't working properly. Their proposed solution was to wipe Windows and do a clean install. We were confident that wasn't necessary, but to give it a go, we used a different SSD on a clean Windows 10 installation.

As expected, the problem was with the 6700 XT sample we received, and when they sent us a different card, it worked flawlessly.

These days, we don't swap GPUs without first wiping the old drivers using DDU. It's a must-have utility for any PC enthusiast, particularly when it's time for a graphics card upgrade. ■

With a whole array of new graphics cards arriving, consider using DDU when it's time to upgrade your GPU.


Options
General Options
Remove present and non-present monitors (Recommended)
Save log files in startup path. (Highly recommended)
Create a system restore point (if allowed)
Store config file in roaming folder
Automatically check for DDU updates on startup (Recommended)
Remove Vulkan Runtime
Show offers from our partners
NVIDIA Specific Options
Remove "C:\NVIDIA" driver folders.
Remove PhysX
Remove 3DTV Play
Remove GeForce Experience (GFE)
Remove NVIDIA Broadcast
(DCH driver) Remove the NVIDIA Control Panel installed from the Microsoft Store
AMD Specific Options
Remove "C:\AMD" driver folders.
Remove the driver/filter AMDKMPFD (A backup is recommended for AMD chipset)
Remove AMD Audio Bus
Remove AMD Crimson Shader Cache folder
(DCH driver) Remove the AMD Control Panel installed from the Microsoft Store
INTEL Specific Options
(DCH driver) Remove the INTEL Control Panel installed from the Microsoft Store
Advanced Options (Change at your own risks)
Enable Safe Mode dialog (Not recommended until you tested Safe Mode manually)
Prevent downloads of drivers from "Windows update" when "Windows" search for a driver for a device.
Close

Here are the options we use when running DDU. Kill it with fire' tends to be our motto!

MAC OS

Control the Home app from Mac

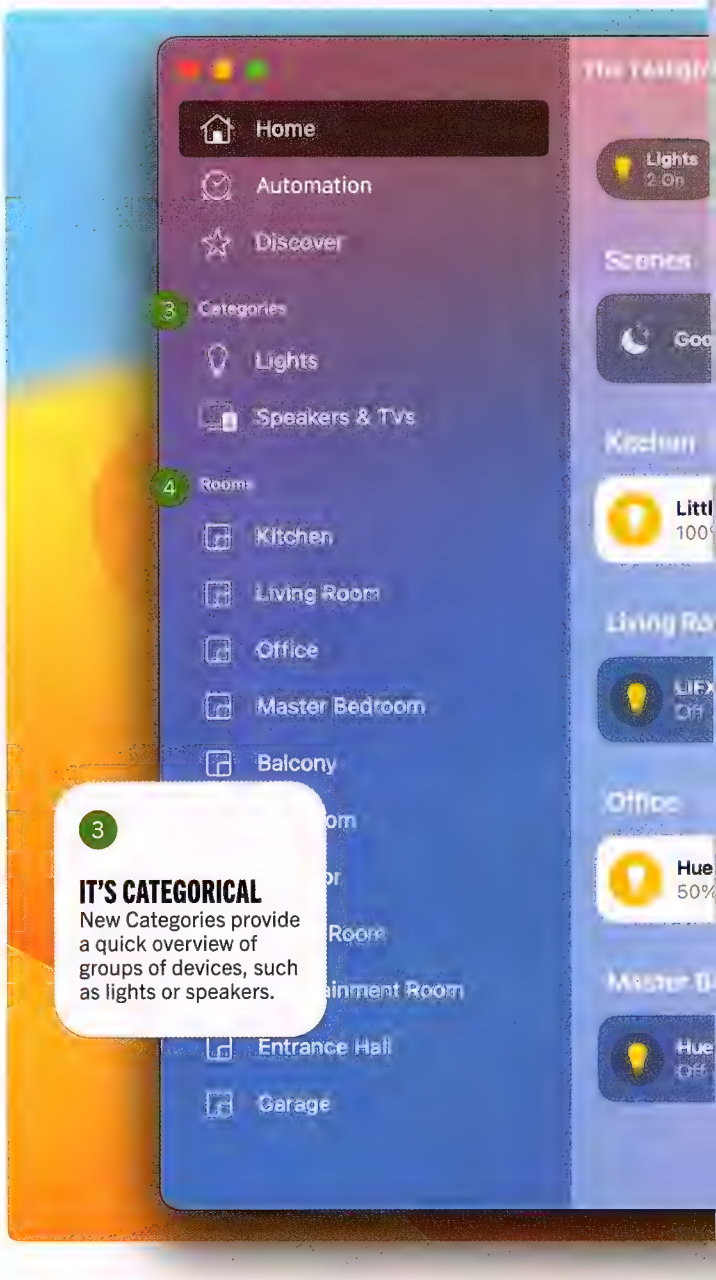
The long-neglected Home app finally gets a welcome revamp for macOS Ventura.

IT WILL TAKE
30 minutes

YOU WILL LEARN
How to control your smart home devices in the Home app on Mac

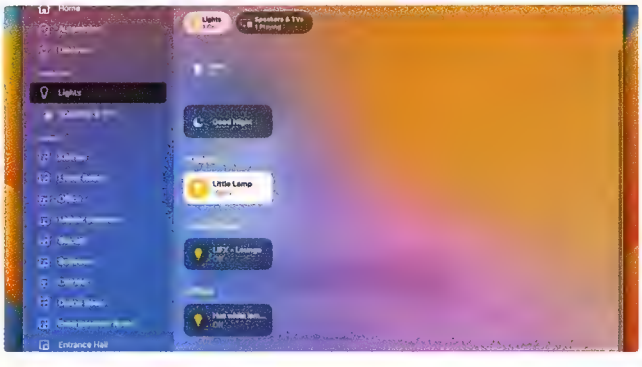
YOU'LL NEED
macOS 13, and one or more HomeKit-compatible smart devices

The Mac version of Apple's Home app has always seemed like a bit of an afterthought – especially as it was only released with Mojave in 2018, two years after the app first appeared on the iPhone. And, to be honest, it hasn't made much progress since then, with Amazon's Alexa attracting far more support from manufacturers of smart lights, security cameras and other smart home devices. But, behind the scenes, Apple has been working with Amazon and other companies over the last couple of years to develop a new smart standard called Matter, that will allow smart devices from a wide range of different manufacturers to work together more easily. So, in anticipation of a new generation of Matter-compatible devices, Apple has given the Mac version of Home a revamp for the release of Ventura.
Cliff Joseph



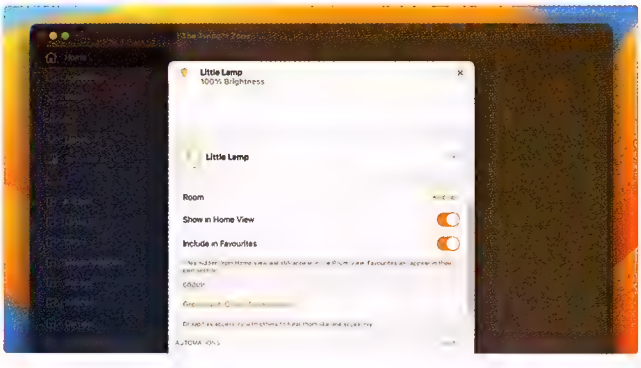
"Apple has been working with Amazon and other companies over the last couple of years to develop a new smart standard called Matter."

HOW TO CONTROL YOUR SMART DEVICES



1 CATEGORIES LIST

The new Categories view displays groups of devices, such as lights or speakers, arranged by room. There's also an overview that shows the status of those devices, and any scenes or automations used to control them.



2 CHOOSING FAVOURITES

The Favourites list hasn't gone altogether – but it's a bit hidden. Click on a device tile to view its information, and click on the gear icon to show Device Settings. Then just click the Favourites button to add it to the list.

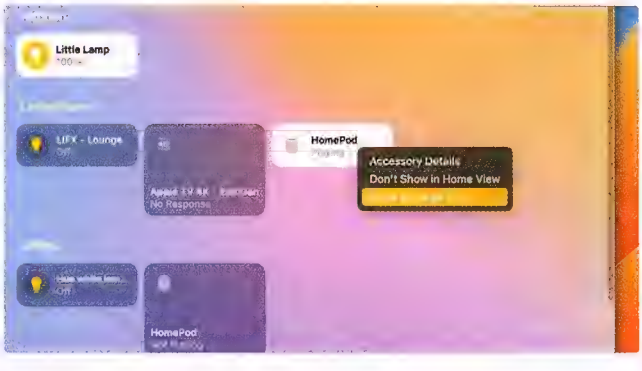
1
MORE DEVICES
Rather than just showing your favourite devices, the main Home window now shows all the devices in all your rooms.
5
Home Settings
5
HOME SWEET HOME SETTINGS
The Home Settings button has been moved, and now allows you to change the order of rooms.
1
Apple TV 4K -...
No Response
2
HomePod
Playing
2
ON THE TILES
Apple wants us all to buy lots of new smart devices, so smaller tiles leave room for more devices.
HomePod
No Response
4
ROOMS WITH A VIEW
The Rooms list hasn't changed, and still lets you view just the devices located in each room.

JARGON BUSTER

Apple's HomeKit software only runs on Apple devices. But HomeKit will also be part of the new Matter standard used in the next generation of smart devices.

GENIUS TIP!

Scenes and automations are tricky to master – but they can monitor the location of your personal Apple devices in order to trigger smart devices when you leave or return home.



3 GOING LARGE

You can also highlight individual devices by making their tile larger. Just control-click on the device tile and select 'Show as Large Tile'. Alternatively, you can hide devices by selecting Don't Show In Home View.

4 MAKING A SCENE

Unfortunately, Apple hasn't made it any easier to use scenes and automations that control multiple devices all at the same time. This is too much like programming for most people – luckily, we'll be looking at this in a future issue.

LINUX

Terminal screencasting

Desperate to show off his terminal prowess, Shashank Sharma puts on his best Darth Vader voice and screencasts to the world live!

Whether it's a cool desktop effect, cleverly designed application or a bizarre problem to be solved, we all have had to capture screenshots at one time or another. Most desktop distributions feature a default screenshot utility, and you have the choice of several more in your software repositories. More often than not, though, the default screenshot utility is limited to capturing either the entire desktop, the active window or a portion of the screen. But what if you could do all three and, more importantly, create a screencast recording of your screen – and all from the comfort of the CLI?

Written in Rust and released under the GPLv3 licence, Menyoki bills itself as a screenshot, screencast utility that can also perform myriad image-related tasks, such as creating GIFs and breaking a GIF into individual files, as well as modifying, analysing and viewing image files.

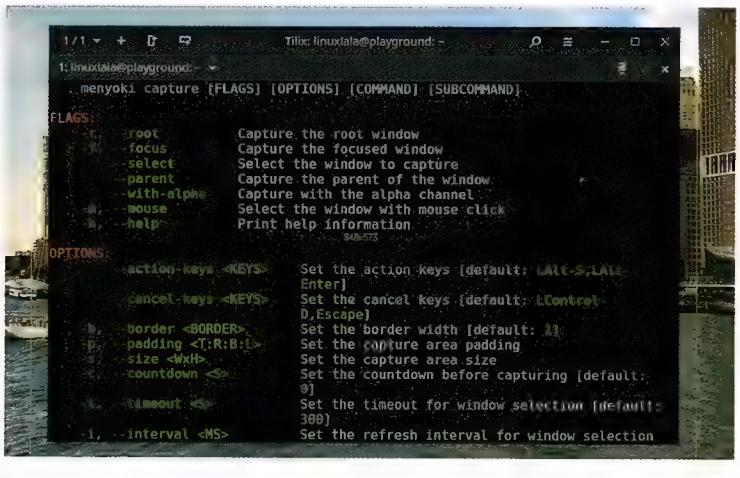
What makes Menyoki stand out is its ability to create a GIF recording of on-screen activities, as well as turn a series of images, such as photos taken on holiday, into a GIF file. You can also break down an animation into individual files, and the tool can double as an image viewer. Menyoki also supports a large number of popular file formats, such as GIF, PNG, JPEG, MP4, BMP, TIFF and more.

Rusty installation

With the exception of Arch Linux and derivatives such as Manjaro Linux, you won't find Menyoki in the software repositories of popular desktop distros, but if you've worked with other Rust packages in the past, or already have your system configured to install packages using the Cargo package manager, you can easily install Menyoki by using the **cargo install menyoki** command

Alternatively, you can grab the latest tarball and extract the files with the **tar xvf menyoki-1.6.1-x86_64-unknown-linux-gnu.tar.gz** command. You can now launch the utility with the **./menyoki** command.

The downside of this method is that you'll have to constantly switch into the directory where you extracted the Menyoki tarball. Moving the menyoki binary into any directory in your $PATH, however, would make it possible to run the utility from anywhere in the Terminal.


Tilix: linuxlala@playground: ~
menyoki capture [FLAGS] [OPTIONS] [COMMAND] [SUBCOMMAND]
FLAGS:
-r, --root Capture the root window
-f, --focus Capture the focused window
-s, --select Select the window to capture
-p, --parent Capture the parent of the window
-w, --with-alpha Capture with the alpha channel
-m, --mouse Select the window with mouse click
-h, --help Print help information
OPTIONS:
-a, --action-keys <KEYS> Set the action keys [default: LAlt-S,LAlt-Enter]
-c, --cancel-keys <KEYS> Set the cancel keys [default: LControl-D,Escape]
-b, --border <BORDER> Set the border width [default: 1]
-p, --padding <T:R:B:L> Set the capture area padding
-z, --size <WxH> Set the capture area size
-d, --countdown <S> Set the countdown before capturing [default: 0]
-t, --timeout <S> Set the timeout for window selection [default: 300]
-i, --interval <MS> Set the refresh interval for window selection

When working with 'menyoki record' or 'menyoki capture' commands, you can use default key-bindings to change the area of the capture.

Capture it!

Menyoki provides all its different functionality through various sub-commands. The project doesn't ship with a man page, though, so we've compiled a quick run-down of the different sub-commands the tool has on offer along with their functions:

SUB-COMMAND	FUNCTION
record	Record an animation
split	Split animation into images
make	Create an animation using images
capture	Capture a screenshot
edit	Edit an image
analyze	Analyse an image
view	View an image
help <sub-command>	Prints help for individual sub-commands

A typical Menyoki command has the **menyoki <sub-command> [FLAGS] [OPTIONS] [ARGS] [SUBCOMMAND]** structure.

As each sub-command can have its own set of flags, options, arguments and sub-commands, you have to run the **menyoki <sub-command> help** command to make the most of Menyoki. For instance, run **menyoki capture help** to read more about taking screenshots.

You can also refer to the project's GitHub page for thorough documentation, which is also home to many examples to showcase Menyoki's functionality.

To capture a screenshot, you have to use the **capture** sub-command. If no output name is provided, Menyoki saves the screenshot as cap.png in your ~/Pictures directory. If you run another **menyoki capture** command, without giving the output name, the previous ~/Pictures/cap.png is overwritten without any warning, so be sure to always provide an output filename when working with Menyoki.

The **menyoki capture** command enables you to define the window or portion of screen you wish to grab using different options. You can run the

OTHER FEATURES

Because Menyoki boasts a large number of features, we can't cover all of them due to space constraints. The project, however, is fairly straightforward to use, with a minimal learning curve, except for the `--size` option, which can require a bit of troubleshooting or trial and error before you get it right.

You can use the `menyoki split file.gif` command to extract individual images from a GIF file using sensible defaults. Alternatively, you can define the output format for the image files, such as JPEG, PNG, BMP, TIFF, and so on, and even define a custom output directory and quality of the image files.

The `menyoki make` command can similarly be used to create a GIF file using a series of image files. In addition to defining the quality and frame rate, you can also get Menyoki to limit the number of repetitions for the resulting GIF file. The default setting is to make the animation run continuously. You would think that Menyoki would use the images in the provided order to create a GIF, but that's not the default behaviour. The tool sorts the files first and then creates a GIF file. You must use the `-n` or `--no-sort` command option if you don't want Menyoki to sort the files before creating a GIF.

`menyoki capture help` command for a complete list of the available flags, options and sub-commands, but we'll list a few essentials:

MENYOKI CAPTURE	FUNCTION
-m	Select the window to capture with mouse click
-f	Capture the window in focus
-t	Set a timeout for window selection
-s <WxH>	Define the capture area size
save <filename>	Save the captured screen
<encoder>	Define the image encoder, whether PNG, JPEG, BMP and so on.

If you prefer to use the timestamp to distinguish filenames, you can run **`menyoki capture -m save "filename.png" –timestamp`**. It's also possible to get more specific help with the **`menyoki <command> <sub-command> help`** command. For instance, run the **`menyoki capture png --help`** command to learn more about additional options available to you when capturing screenshots using the png encoder.

Recording screencasts

If no output file name is provided, **`menyoki record`** creates a ~/Pictures/rec.gif file of 20 frames by default. Many of the command options are the same as with **`menyoki capture`**, such as **`-m`** to select the window by mouse-click, **`--size`** to define the size of the screen to record, and you can use **`--duration`** to define the time in seconds. It's also possible to deploy advanced recording features with different flags. You can use **`--fps`** to define the number of frames per second to be recorded, and the quality of the recording can be controlled with the **`--quality`** flag.

The command **`menyoki record -m --size 300x450 --duration 20 --countdown 10 save "screencast.gif" --timestamp`** utilises some of the popularly used options and flags with the **`menyoki record`** command.

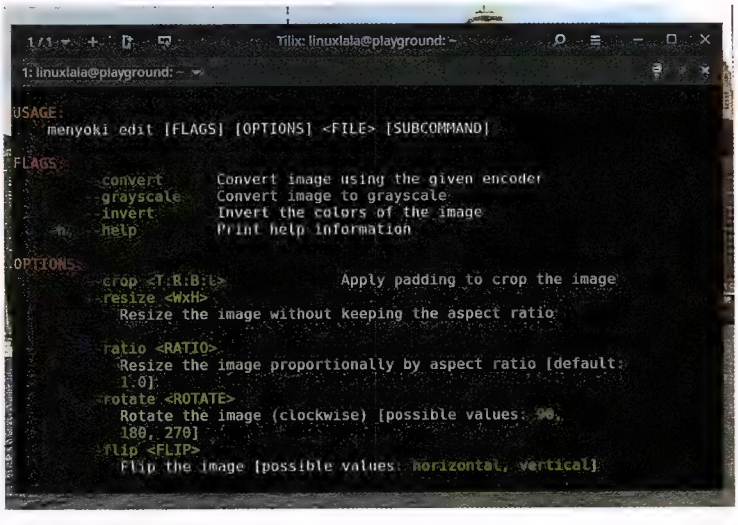
You can also use Menyoki to record the output of a command, without having to set it up first as in the example above. Instead, run **`menyoki -q record "command" save "gif-of-command.gif"`**. This can be helpful when you're on a forum and asked to provide the output of a command to troubleshoot a problem.

Menyoki offers key-bindings that you can use to increase or decrease the size of screen when working with the record or capture commands. You can also reposition the capture area, without changing its size.

KEY-BINDING	FUNCTION
LAlt+arrow keys	Increase the padding, thus reducing the capture area
LAlt+LCtrl+ arrow keys	Decrease the padding, thus increasing the capture area
LShift+LAlt+ arrow keys	Reposition the selected area
LAlt+Enter/S	Start or stop recording the selected area

Finally, Menyoki's image-editing capabilities cover most commonly used operations, such as brighten, blur, contrast, crop, resize, rotate, flip, blur and more.

Named after the author's favourite character in the *Patapon 2* game, Menyoki is definitely one tool that can be frustrating if you try to rush into it without spending time with the documentation. ■


1: linuxlala@playground: ~
USAGE:
menyoki edit [FLAGS] [OPTIONS] <FILE> [SUBCOMMAND]
FLAGS:
convert Convert image using the given encoder
grayscale Convert image to grayscale
invert Invert the colors of the image
help Print help information
OPTIONS:
crop <T:R:B:L> Apply padding to crop the image
resize <WxH>
Resize the image without keeping the aspect ratio
ratio <RATIO>
Resize the image proportionally by aspect ratio [default: 1.0]
rotate <ROTATE>
Rotate the image (clockwise) [possible values: 90, 180, 270]
flip <FLIP>
Flip the image [possible values: horizontal, vertical]

You can use 'menyoki edit' to perform various image editing operations, such as convert, greyscale, rotate, flip, blur and so on.

PI

Make a model train scale-speed monitor

Sean Conway feels the need for scale-model speed! So, he prototypes a Raspberry Pi-based measuring device with a few basic sensors.

YOU'LL NEED THIS

- Raspberry Pi 3 B+
- 16GB SD card
- Raspberry Pi OS Lite (used: 4 April 2022)
- GPIO Zero 1.6.2
- IR sensors

Have you ever seen something and thought, "I can do that"? This writer's inspiration came after using a commercial device to determine the speed of a model train. The speed limit posted for a real train entering a siding is 16kph.

So let's use a Raspberry Pi, with some external infrared (IR) sensors mounted to a block of wood of known dimensions, to establish the scale speed of a model train entering the siding on a model railway layout.

Typical full-size trains run at up to around 100kph, depending on limiting factors. The class or track quality determines the maximum running speed and the ability to carry passengers. Other factors, such as curvature, signalling, track condition and level crossings, may also influence the speed. Model train sets take the full-size train and scale it down to a specific model train scale. Today, OO and N are the most popular scales. The letters represent ratios – the fraction that is used to scale or model the environment. Scale not only applies to the train size but also to scenery, so that everything in a layout is in proportion to its real-life size.

Model railroad enthusiasts want their model railroad to resemble the appearance and operation of a full-sized real railroad. The hobbyist strives to have the train run at scale speed on the layout. Scale speed represents the model speed for what the actual speed would be for a life-size train.

In the diagram above, the distance between the two infrared sensors is known. If we start a timer when the train crosses the start counter sensor and then stop the timer when the train crosses the stop counter sensor, we have data that can be used to determine the time it took for the train to travel the distance. The full Python code for this tutorial is available from **tinyurl.com/APClinuxfiles**. We just explore a few snippets of it here to understand the operation.

> "Model railroad enthusiasts want their model railroad to resemble the appearance and operation of a full-sized real railroad. The hobbyist strives to have the train run at scale speed on the layout."

We need two GPIO inputs to read the sensors. From the GPIO Zero library, the code uses the **LineSensor** class to determine the sensor status. The **LineSensor** class reads the sensor and produces an output showing when the sensor has been triggered.

The code conditions the sensor output as a pull-high. An internal resistor keeps the output high and it goes low when triggered.

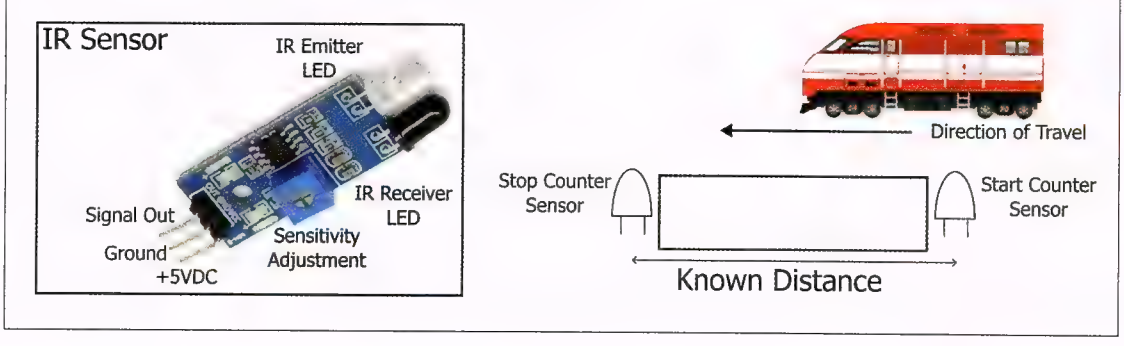
Determining the specific time elapsed for the train to pass both sensors is crucial if we want our device to provide accurate readings. The Python time library provides various time-related functions; **perf_counter** is a clock with the highest available resolution to measure a short duration. It is ideal for measuring the time elapsed between two intervals. It supplies a value in fractional seconds of a performance counter.

The most common units of speed are kilometres per hour (kph) or, in the US and UK, miles per hour (mph). To cover both, the constants required to calculate kph or mph are provided, along with the scale value. Four functions are now defined in the code: **start_time_counter**, **stop_time_counter**, **speed_calculator** and **counter_reset**:

```
def start_time_count():
    print('start sensor triggered')
    global timer_start
    global start_count
    if timer_start == False:
        start_count = perf_counter()
        print(start_count)
        timer_start = True
```

The **start_time_counter** and **stop_time_counter** take a reading of the performance counter when their respective sensors are triggered. Subtracting the start count from the stop count provides a floating point value of the time it took for the train to travel between the two infrared sensors.

```
def speed_calculator():
    .....
    if timer_start == True and timer_stop
```



Two IR sensors are used to generate the all-important start and stop count.

```
== True:
        elapsed_time_sec = stop_count
- start_count
        miles = sensorSpace_
inch/63360
        kilometers = sensorSpace_
mm/1000000
        hours = elapsed_time_sec/3600
        mph = miles/hours
        kph = kilometers/hours
        scaleMPH = mph*modelScale
        scaleKPH = kph*modelScale
        print('Elaspsed time in seconds:',
elapsed_time_sec)
        print('Miles:', miles)
        print('Kilometers:', kilometers)
        print('Hours', hours)
        print("Speed in MPH:", mph)
        print("Scale Speed in MPH:",
scaleMPH)
        print("Speed in KPH:", kph)
        print("Scale Speed in KPH:",
scaleKPH)
        counter_reset()
```

The stop/start time counter subtraction and the calculations to determine both the actual speeds and the scaled speed are done in the **speed_calculator** function. Besides the calculation, the code outputs the values to the terminal window. With the calculations and display complete, the counters are reset to await another reading. The main body of the code is reading the **LineSensors** to determine whether they have been triggered and record that all-important count to determine time.

Remember that this model train speed measurement project came from an "I can do that" moment. The code is not robust enough and would require further development to handle errors and additional use cases. Lines of code in the script perform a small test to ensure that the start count is before the stop count, or the code errors. The code is written for the train travelling in one direction only. The commercial speed device deployed provided a speed reading with a train travelling in either direction.

Another issue with this design was the sensor location. Initially, sensors were attached to each end of a five-inch block of wood using the module screw holes. The block of wood positioned the sensor low down on the moving train, trying to get a reflection from the truck assembly. This resulted in poor performance because of false triggers. When the sensor block was repositioned higher on the train, so the body of the train was reflecting the infrared light, the readings stabilised.

Here's the start IR sensor in position to trigger the python start_count function.

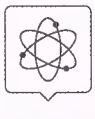
Another poor performance contributor was the threshold setting for reflective distance. The trimpots were adjusted to ensure the sensor triggered reliably. Unfortunately, when the sensor block was moved, that calibration of the sensor had to be redone.

The commercial device had TX and RX sensors located across from each other. The train passing between the sensors interrupted the signal, resulting in a trigger. Since the commercial device was positioned completely over the track, and the train passed through it, the sensors' sensitivity was never an issue.

The commercial speed device was also a battery-powered portable device. Given sufficient resources, it could improve the Raspberry Pi design to run it off a battery and contain a small screen to display output.

The device worked successfully despite the design limitations, feeding the time values produced from the Python code into a train scale speed calculator found on the internet. Setting the distance in the calculator to the spacing of sensors on the block of wood, and then inputting the time given from the Python code, the online calculator provided scale kph and mph speeds. Readings were within 10 percent.

Constantly measuring speeds of model trains is not typical of a layout. Once the scale speed is determined, the CABs used to control the train are programmed to use the appropriate scale speeds. Now, with a few sensors connected to a Pi and some Python code, you have your own model train speed-measuring device. ■



GENIUS TIP!

GPIO Zero is a simple interface developed and maintained by Ben Nuttall (**https://bit.ly/lxf296gpio**).

INFRARED SENSOR MODULES

An infrared (IR) sensor has a small circuit board with three pins: VCC, GND and OUT. VCC is connected to a 5V DC pin on the Pi, GND goes to one of the ground pins on the Pi, and finally OUT is connected to the GPIO specified.

The sensor has one diode that transmits (TX) IR light and a second diode that receives (RX) it. When the transmitted infrared energy hits an object, it is reflected, and when received, it triggers the sensor output. A trimpot adjusts the threshold distance that causes the sensor output to change.

How fast can a model train travel? The child in us might give in to the temptation to wind up the throttle to the max and have the trains speeding round and round the track. However, derailments and crashes as a direct consequence of operating trains at faster speeds can cause costly damage to expensive trains. Play safe out there, kids! Don't anger the Fat Controller!

GAMES

Warhammer 40K: Darktide

Bash heretics to save a wonderfully horrible world.

■ $59.95 | PC, XBS/X | playdarktide.com

apc HIGHLY RECOMMENDED

Just like *Vermintide* before it, *Darktide* is not about the most powerful characters in the setting. That's not to say it doesn't make you feel powerful, but it's a kind of measured power. A handful of Space Marines could probably free Tertium by lunchtime, but alas, it's up to you and your band of misfits to save the hive; or what's left to be saved anyway.

First off, it's important to acknowledge how *Darktide* is different from Vermintide. The game represents a shift in Fatshark's storytelling – where *Vermintide II* depicted the past exploits of the Ubersreik five, in *Darktide* you are part of a developing narrative. As it stands, *Darktide* feels more like a prologue or a first chapter right now, introducing you to the hive and the not-so-friendly faces of Rannick's Inquisitorial band.

For those familiar with *Vermintide II*'s skull-splitting melee antics, *Darktide* will feel like chatting with an old friend, until that friend pulls out a lasgun and vaporises your face. As you happily slaughter your way through Tertium's cramped corridors and gloomy halls with an array of 40K weapons, you'll eventually come face to face with a squad of heretic troopers armed with guns. They'll be just beyond your smacking range, and as you try to close the distance and get shot up, you'll understand *Darktide*'s challenge.

Dealing with distance and ranged enemies is the game's most significant hurdle, but there are multiple ways to approach it. A Veteran Sharpshooter might pick off ranged units from a distance, or the Ogryn may use their riot shield to tank incoming shots for the squad. My personal favourite is the Zealot, dashing at enemies in-between volleys to bring them into melee. Not that ammo is in short supply: there are so many bullets now, maybe even too many. After *Vermintide II*'s stingy ammo economy, I don't feel right leaving ammo behind, but sometimes my gun is just plain full.

With so many more variables in terms of ranged threats, special enemies, and the tools you have to deal with them, *Darktide* is the most comprehensive iteration of Fatshark's formula yet: fast and fluid as you move point-to-point, threat-to-threat. Classes also feel like they have defined strengths, and the introduction of the buffs and shield regen that you get in close proximity to your squad are a welcome incentive for team-based play in matchmade missions.

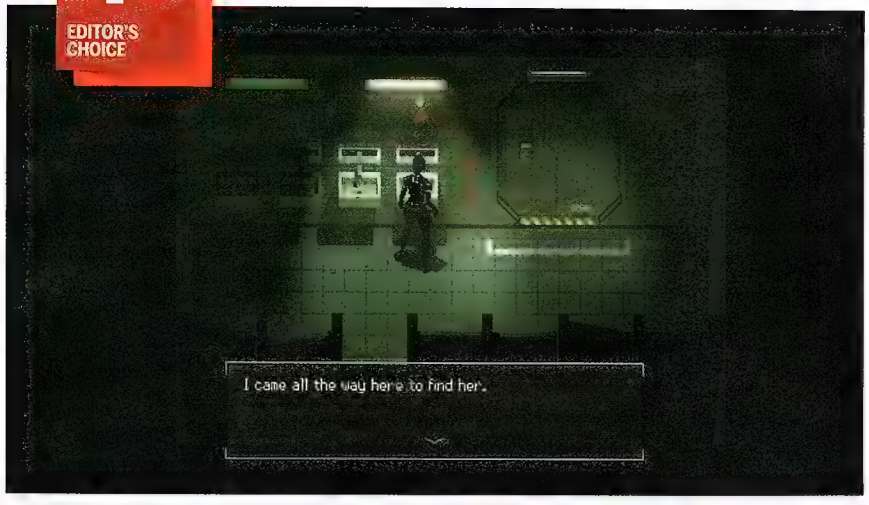
While the combat is certainly better, the lack of a full crafting system on release is a step back from Vermintide, and wasn't the best way to showcase *Darktide*'s amazing arsenal. However, the UI has been significantly tweaked since the pre-order beta, making it a lot easier to understand how weapons actually work and what they're good for.

Though *Darktide* needs more time to develop, its core gameplay is the best iteration of Fatshark's formula yet.

Sean Martin

★★★★☆

apc EDITOR'S CHOICE



SIGNALIS

One of the best psychological sci-fi chillers in years.

■ $29.95 | PC, Switch, PS4, XB1/S/X | rose-engine.org/signalis

Signalis will feel familiar to anyone who played PS1 survival horror games. Viewed from an overhead perspective, there's a labyrinth of interconnected rooms to explore, many locked doors, logical and more abstract puzzles, and an assortment of monsters to shoot. Inventory space is at a premium, healing is finite, and the game can only be saved at safe-rooms.

Aesthetically, it refines that PS1 style. Backdrops are crisp pixel-art while characters are smoothly animated 3D. The retro-tech UI is similarly sharp, featuring an especially good map screen, automatically marking doors as locked, barred or open. Audio-wise, it channels Akira Yamaoka, with industrial drones accompanying quieter moments, chaotic, panicked noise kicking in during combat, and an assortment of nostalgic tones accompanying menu actions.

Combat is tense and resource-limited, encouraging evasion and ammo-hoarding. Puzzles stall progress just long enough to deliver a eureka moment. The only truly unfamiliar mechanical element is the radio tuner, allowing you to decode radio signals. Sometimes creepy numbers stations, often puzzle hints, and occasionally frequencies used in combat.

Resident Evil 1's remake is borrowed from directly, including 'panic items' for escaping close combat, and a limited supply of incendiaries to burn corpses. While similar to *Resident Evil* mechanically, Signalis' atmosphere hews closer to Silent Hill, telling the story of a lone technician android named Elster descending into metaphorical hell in search of her missing co-pilot.

While *Signalis* trades in familiar sci-fi horror tropes, this is psychological horror. It's a character-driven, emotional story, intentionally fragmented and dreamlike. A downward spiral following a potentially unreliable narrator.

Even after completing it twice, the only real complaint I can level at Signalis is that inventory management is a little too fiddly. Elster can only carry six items. Leaving healing items behind and only carrying one gun can help, but backtracking to item boxes is nigh-inescapable. Despite this one wrinkle, *Signalis* is one of the best horror games I've played in years. Tense, upsetting and thought-provoking.

Tense, haunting and beautiful. Inventory shenanigans aside, one of the best survival horror games yet.

Dominic Tarason

★★★★½

SUNSET SHIFT

Bin there, dumped that.

■ Free | PC | bit.ly/SunsetShift

Sunset Shift is set on a beautiful island that has been commandeered by the rich elite, who holiday in villas in each of the island's four scattered towns. All you have to do – in a ridiculously well-paid job – is spend a couple of hours each day collecting their rubbish.

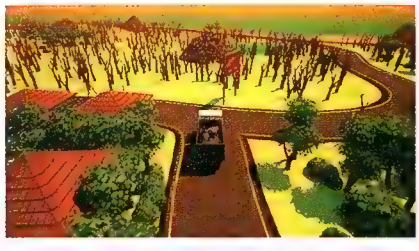
You spend the game in the confines of a bin lorry, navigating winding roads as you meander from town to town. The roads are well laid out, with the towns being built on a circuit that you can take clockwise or anti-clockwise, so you can more or less zone out and enjoy the chilled soundtrack as you do your job. Pretty soon, as time goes on, the mounds of crap become bigger and more numerous, and they begin to wither the trees. At the end of the game, the island is such a dump that it becomes uninhabitable.

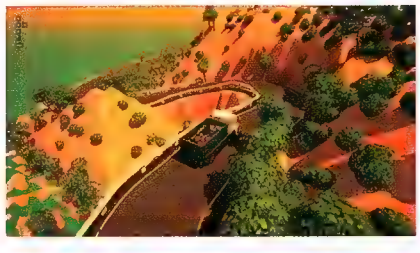
It mirrors the climate crisis in the real world: from wacky conspiracy theory to impending apocalypse. *Sunset Shift* captures our selfishness, our collective willingness to turn a blind eye remarkably well.

An incredibly subtle game with a strong message, but unfortunately it's a bit tedious to play.

Tom Sykes

★★★½☆





MAPFRIEND

Makes a game out of Google Earth.

■ Free | PC | bit.ly/MapFriend

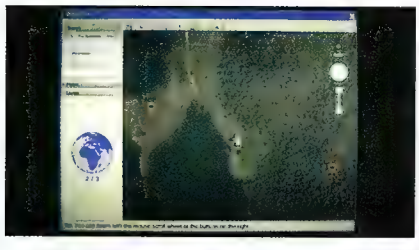
Google Earth has finally been turned into a horror game, where a dark secret hides behind a cute mascot and a low poly veneer. The concept is that this is Google Earth if it came about in the 1990s. So it has a delightfully boxy, Windows 95-style interface, and all the scenery is pixelated to hell. You can't explore the whole Earth, of course, but a few rural locations, which are barred on all sides by impassable barriers.

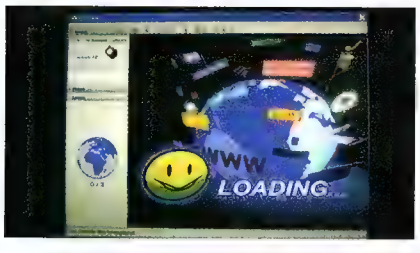
You're trying to locate giant pins that will dole out 'fun facts' when clicked on. They'll also reveal gamey Explore Orbs, which you have to chase and collect to unlock the next location.

When the horror comes, it's by cleverly glitching out that interface, taking you to unsettling locations and flashing up lore that suggests a dark backstory. I appreciate the brevity, but I would have also liked more of this horror element. Fingers crossed *MapFriend*'s premise is eventually explored in much greater depth, as there's not quite enough of anything to sink your teeth into here right now.

A fresh concept that needs a little work.
Tom Sykes

★★★☆☆





THE CALLISTO PROTOCOL

Walk down gaming's moodiest corridors.

■ $89.95 | PC, PS4/5, XB1/S/X | callisto.sds.com

Working man pilot Jacob Lee has crash landed on the dead moon of Callisto, after his cargo ship is boarded by a notorious terrorist group. First, he discovers his colleague has died a gruesome death during the crash. Next, Lee is arrested, and he has a long life spent in the moon's Black Iron prison to look forward to. But then the prison falls afoul of some mysterious disaster that turns its inhabitants into crazed mutants.

The stakes are clear: Lee is in deep shit and must dig himself out of it. *The Callisto Protocol* wastes no time cementing the terror of its setting. Now we just need to walk through corridors for 15 hours and butcher our way through it.

The GRP is *The Callisto Protocol*'s answer to Control's levitate, or Half-Life 2's gravity gun, and it's great fun. In a game full of spongey baddies, this weapon lets you pick most of them up and toss them off platforms and into chasms, or more regularly, into wall-mounted spikes.

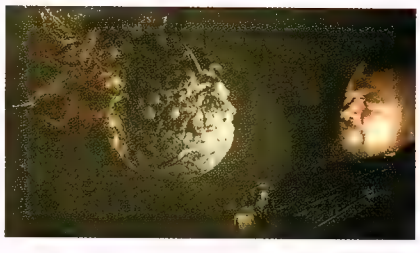
I didn't find any of the baddies especially scary, if only because I've played a lot of horror games with enemies just like these, but there are a few loathsome predators that were the exception. It's not the appearance of these more fearsome mutants that's threatening, but how they move around the environments. There's also the ever-lingering threat that if you don't shoot the emerging tentacles off a mutant they'll morph into something more formidable.

> "*The Callisto Protocol* is riddled with cinematic videogame cliches."

The Callisto Protocol is riddled with cinematic videogame cliches. Yes, you'll navigate a crumbling structure that will start to collapse as you cross it. Yes, you'll need to power on a generator by finding breakers that are located in different locations. *The Callisto Protocol* feels like a new, albeit well-qualified studio, singing to the crowd, "We can make these kinds of games that you really, really want." And we, the crowd – most of us anyway – will sing back, "Yes, you can, keep on going."

Gory and grim in equal measure, *The Callisto Protocol* doesn't mess with the survival horror formula.
Shaun Prescott

★★★★☆



FLOODLAND

Beginning at the end in a soggy citybuilder.

■ $44.95 | PC | ravenscourt.games

Floodland, in a lot of ways, is an epilogue to the traditional citybuilder. Civilisation is in ruins as a result of climate change, and now you have to rebuild with the flotsam and jetsam we left behind. There's no lush, untouched meadow to stick a motorway on, as in *Cities Skylines*. There are a lot of smashed-up cars and collapsing houses, rotting boats and wonky skyscrapers, and you'll plunder all of these to rebuild society, for good or ill.

It might be a world of scattered islands in a flooded apocalypse, but at the start you're almost overwhelmed with resources. Build Sorting Huts to collect the rubbish, Fishing Docks and Field Kitchens to get food, and Water Purifiers to bring in clean drinking water.

Every band of stragglers added to your settlement is a blessed relief. Phew, that's ten more pairs of hands to work in the Insect Hut, and the Baker Station, and the Study to generate research points – but each insists on having a home, food and water. Alas, those bountiful resources don't last forever. While some things do respawn, at some point you'll need to expand to another island.

Floodland's message might be one of unity, but that doesn't mean it's easy to implement. You start the game with one clan, but as more are integrated, tension rises. Each is represented by a talking head, who will pop up to let you know how badly the clans are getting along.

Despite its overall tone of hope, *Floodland* doesn't pull any punches when it comes to its survival mechanics, demanding constant micromanagement. Rebuilding society is hard work, but ultimately it felt gruelling as I was juggling fish supplies and wood shortages and multiple bickering clans, while having to deal with the glacial pace of technology acquisition.

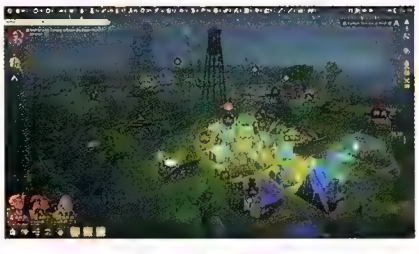
> "*Floodland*'s message might be one of unity, but that doesn't mean it's easy to implement."

Floodland is an exhaustive (and exhausting) game of survival, expansion and politics, and it can be satisfying keeping on top of the logistical problems. Sadly, with its unlikeable talking heads, it just didn't give me enough of a reason to care.

Performance and pacing problems mar an otherwise novel and comprehensive survival citybuilder.

Tom Sykes

★★★☆☆



FACE DOWNLOAD

Beating a demon at his own game.

■ Free | PC, Mac, Linux | prsas.itch.io/face-down

You've made a deal with the demon who stole your partner's face: if you win at a game of cards, she'll be freed. But if you lose, the creature will add your face – and indeed your immortal soul – to his repertoire, slipping it on as easily as a mask.

It's a strong setup for a relatively simple card game, and the demon's taunting and grotesque appearance do a lot to reinforce that the outcome matters. Win, and the demon is bound to his word. Lose and you're bound to yours. I played twice and arrived at both (satisfying) outcomes.

Essentially, all you're doing is comparing cards. You can have two cards in your hand at once, and the highest number wins when one is plonked on the table. Every victory is worth points, and whoever reaches 100 points first wins.

But the demon quickly makes things more interesting. He randomly applies rules that both sides have to abide by: you can't play two odd numbers in a row, you can't play your left card if it's even, that sort of thing.

This is a macabre and tactical card game with one hell of a premise – and opponent.

Tom Sykes

★★★★☆

GAME CHANGER

The Witcher

A dodgy RPG propped up by a now popular universe. By Lauren Morton

■ **Release:** October 26, 2007 **Developer:** CD Projekt Red **Publisher:** Atari **Link:** thewitcher.com

Even in its late-2000s prime, CD Project Red's first *The Witcher* game could have been accurately (but affectionately) referred to as eurojank. It was, at the time, an overly-ambitious homage to a niche fantasy series with atrocious voice acting and even worse character models that had no business becoming the success story it is today. I can't even pretend it's aged well – not when its peers are buggy but enduring classics like the original *Mass Effect* and *Fallout 3*. And especially not with CDPR announcing that a remake of the original game is now in the works.

For years I've told any friend who asks me about the original *Witcher* game that they should start with *The Witcher 3: Wild Hunt* and then circle back to the beginning of the series after they feel some investment in Geralt and the world around him. I'd still not recommend it as anyone's first experience, but the success of Wild Hunt, the renewed interest in the *Witcher* books, and Netflix's series adaptation makes it so much less likely for it to be anyone's first time watching Geralt battle a striga and a lot easier for me to recommend with that in mind.

First blood

I roasted *The Witcher* the first time I played it and I'll not pretend it didn't deserve it. As a first introduction to the universe, the charm was sparse. *The Witcher* intentionally begins with Geralt being inflicted with amnesia, as is plenty common for RPG protagonists, and then misses the point of that trick entirely by introducing proper nouns at an untenable pace for anyone who hasn't already heard names like Oxenfurt and Stregobor tossed around. It got confusing.

Its rhythmic sword swing combat is clunky at the best of times, often enticing me to point Geralt's view down at the indicator ring around an enemy's feet where their health is shown instead of at my surroundings. The game crashes frequently. Its UI gets locked up an infuriating amount. The least ugly of its characters are alien and bug-eyed even by 2007 standards – most horrifically the tragic mug of Zoltan Chivay. The voice acting is not uniquely bad for its time, but perhaps uniquely committed to lines delivered like a first time *Dungeons & Dragons* group dictating their character backstories as speech to text.

Even Doug Cockle's performance as Geralt is so stilted – and not just as a nod to the dampened emotions of Witchers – that I once assumed he'd been recast by the time of *Wild Hunt*. No, that's for sure the same guy. Like CD Project Red's series as a whole, Cockle's performance improved throughout the trilogy more than anyone would have predicted after the original.

But like a tragically awkward grade school photo you'd have burned if asked at fifteen but feel a certain

fondness for by 30, *The Witcher* has grown on me since I first played. The awkwardness is not forgotten. If anything I'm now more attuned than ever to the fact that I'll never pull off blunt bangs and that *The Witcher* is an equally dishevelled mess. The benefit of hindsight is seeing the glint of future success where I'd missed it before.

Parried problems

Coming back to *The Witcher* years later and seeing some of the stories adapted into both CDPR's games and Netflix's show, it's so much easier to look past the initial deluge of Termerian politics to see the thematic groundwork that the first RPG genuinely got right. Even in the first chapter of *The Witcher*, the consistent theme of 'monsters are a threat but it's humans who are monstrous' comes through clearly. As a first experience, I remember focusing on how I couldn't quite get myself to care about the Church of the Eternal Fire or keep straight the difference between the Scoia'tael and Salamandra. I've come to appreciate the political fantasy more as delivered by Henry Cavill's live-action rendition, but originally found it unapproachable without a better primer to start with.

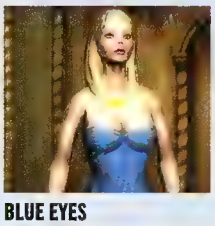
Now though, the politicking fades into Geralt's background and what comes into focus is the lesson that I'm now so used to *The Witcher* delivering. Geralt consistently has the option to protect the same monsters he's been paid to kill from humans who've committed greater evils. The main quest for its first chapter is literally titled Of Monsters and Men, a pretty overt declaration of intent that I just wasn't focused on when I first busied myself with the more game-y particulars of learning *The Witcher*'s combat and potion brewing systems.

The Witcher's first chapter is mainly focused on slaying uncomplicated monsters and leaving the grey morality to all its humans. Geralt uncovers a lot of ugly truths while exploring the outskirts of

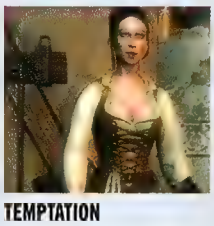
QUEST PRACTICE

Don't miss these secondary stories

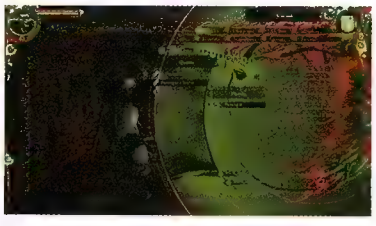
BEAUTY AND THE BEAST
A quest to save a woman's lover from lycanthropy leads Geralt on a goose chase of possible cures, unless he chooses a deadly solution.



BLUE EYES
The missing sister of a knight turns up as a vampire's thrall in an unlikely location, ultimately forcing Geralt into an ultimatum.



TEMPTATION
Geralt's help is requested by the wife of a blacksmith who has taken up an affair with a succubus, though she and her husband have different solutions in mind.



The Kaer Morhen crew is out in force in *The Witcher*'s prologue.

Above: The text size increase mod has genuinely saved my eyes. **Right:** The game's opening cinematic, however, looked pretty swell.

Vizima: no less than child trafficking, sexual assault, suicide and a questionably innocent but definitely negligent local witch.

In later chapters *The Witcher* gets pulled into making other familiar decisions about the humanity of monsters themselves. Geralt's habit of taking contracts that turn into mysteries is plenty present in later chapters too. It's all familiar ground for anyone that's already gotten their foundational Witcher knowledge elsewhere.

Of monsters and mods

For all that I'm willing to forgive many of *The Witcher*'s stylistic faults, there are plenty that can be solved with mods. The Witcher Texturen Mod has been around for over a decade, a well-regarded fan choice for sharpening tons and tons of environmental and monster textures in the game. I still maintain that no amount of texture sharpening or upscaling can detract from the specifically 2007 vibe of every house and inn's wide open layout, stingily decorated with an approved number of barrels and other objects.

Similarly, modders can only do so much to improve on the character faces in CDPR's first RPG but The Witcher Hi-Res Character Models is about as good as it gets. Geralt does look a bit better, but putting more pixels on Zoltan's face just doesn't solve his issues.

My biggest mod preference for the original *Witcher* game sounds initially trivial, but I can't overstate what a difference bigger fonts can really make. My personal favourite is descriptively titled Text Size Increase for Higher Resolutions, because I can overlook some outdated character models but I literally cannot look past fonts that are too tiny for my myopic eyes to read on my very modern 2560x1440p monitor.

If you're more of a one stop shop mod installer, The Rise of the White Wolf is an overhaul that covers tons of character retextures and redesigns the game's interface too. I've got a soft spot for the original green and red interface but if you like a sleeker look the Rise of the White Wolf provides.

Which Witcher?

With CD Projekt Red's planned remake of its original *The Witcher* coming sometime in the next several years, the original 2007 RPG may become a relic. For most players, that remake will be worth waiting for. We don't know yet how much CDPR plans to change, though I have my doubts that its idiosyncrasies like the timed sword swing combat will survive.

I find myself making caveats and excuses for the first *The Witcher* game so often now, so much so that a friend said "I thought you hated it," when I mentioned I was replaying it and couldn't give a much better answer than, "I sort of do...but." I'll defend the silly sword combat with my honour now that I've survived it myself.

The Witcher remains a game that I can't quite call a classic on its own merit. But as a supplement to a series that's expanded so far beyond it, I can't help smiling at situations that strike me as 'classic Geralt'. ■

RETRO

What makes retro OS developers click

Developers are working on new operating systems for old computers, adding features and eye-catching GUIs. But why do it at all? David Crookes investigates.

Switch on an 8-bit computer from the 1980s and you're likely to see a "ready" prompt. As an APC reader, no doubt you have a good idea of what to do next, but most people would struggle. After all, these machines were created in the days before the graphical user interface (GUI) was commonplace. Computers had a much steeper learning curve as a result; it's just we didn't realise it at the time.

"The original 8-bit operating systems of the early 1980s were mostly BASIC programming language interpreters with additional DOS features," recalled Jörn Mika, a digital creator from Germany. "You could either start developing your own programs right away or simply run programs from tape or floppy disk, but it wasn't frustrating since you didn't know anything other than a command line."

However, by the mid-1980s developers were understanding how unfriendly those interfaces appeared. Taking cues from the first GUI that had been developed at Xerox PARC for the Alto personal computer, as well as the commercial Xerox Star workstation that followed in 1981, GUI OSes soon became standard.

This was thanks in no small part to a young Steve Jobs, who was inspired by the Alto GUI to spearhead development of the Apple Lisa, the first computer to present a GUI to the public in 1983. Microsoft then followed suit with Windows in 1985.

"In the second half of the 1980s, I saw the Amiga Workbench and was very sad that I didn't have such a wonderful system with multitasking and GUI on my 8-bit machine," Mika said. "It seemed this would be possible only on a more powerful computer."

Above: The OS of the Amstrad CPC 464 is a far cry from the GUI interfaces of today.

Since then, Mika, who bought an Amstrad CPC 6128 in 1987, has proven his own hunch wrong. In 2001, he started work on a GUI-based 8-bit OS of his own, marking the start of the SymbOS project. It showed his computer didn't need to be as powerful as he imagined.

SymbOS has since been developed not only for the CPC but MSX, the Amstrad PCW and Enterprise 64/128. It has provided an alternative to the baked-in OSes of the original machines while adding a lot of extra features.

"It was always my dream to have a system like the Amiga Workbench on the Amstrad CPC and, in the late 1990s, I discovered that such a system was possible if you implemented some key functions in a very optimised way," he told *APC*.

"In the beginning, the must-have key features were just a Windows-like GUI and pre-emptive multitasking with process privatisation. It was also important to have the GUI elements pixel-based and to be able to update background windows even with partial occlusion. The main memory needed to be managed dynamically up to the maximum expansion, too."

Great zeal

SymbOS is by no means alone in providing a GUI OS alternative for 8-bit machines. In the early days, we saw the likes of GEOS, the OS designed for the C64, C128 and Apple II that resembled the classic Mac OS. More recently, among others, there's been Zeal 8-bit (an open-source OS for the Z80 chip written in assembly) and the Atari 8-bit Graphical OS (GOS).

"Atari 8-bit GOS was initially envisaged as a graphical UI library for standalone programs before the scope broadened to first provide a DOS overlay then a complete operating system with pre-emptive multitasking," said creator Jonathan Halliday, a 49-year-old self-employed IT freelancer from South Shields.

"The intention was to see how far a system based on a 1.79MHz 6502 CPU could be pushed; whether it could operate a windowed UI at reasonable speed, and – later – whether it could run a pre-emptively multitasking microkernel. Some third-party commentators – misunderstanding how microkernels and GUIs work – were convinced it could not be done, and I was keen to prove them wrong."

Halliday has incorporated a pre-emptively multitasking micro kernel into his OS as well as a rectangle-based overlapping window manager and simulated hardware-sprite mouse pointer, while emphasising speed and presentation. Up to 16 processes run concurrently and share CPU and memory resources.

"The GOS currently exists as a proof-of-concept demo with very limited functionality but performance and responsiveness is comparable to that of much more powerful machines," he said, confessing the project – which began in 2011 – has been neglected for some years.

"I hope to return to the project soon since I recently completed FAT file system drivers written in 6502 assembly language for another project, and these same drivers will eventually form the basis for the GOS file system drivers," he said.

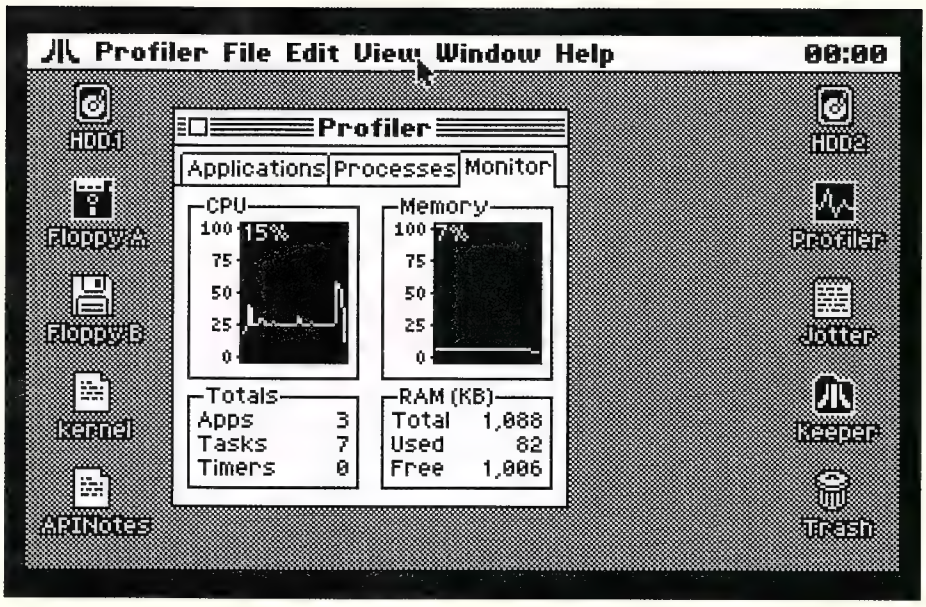
What's remarkable is how long some of these OSes have been in development. Another, FutureOS, began life on the CPC in 1991 at the hands of Dr Stefan Stumpferi, but has since been adapted for the little-sold Amstrad 6128 Plus computer to make use of that machine's extra capabilities.

The latest version, unveiled in February 2022, supports up to 4MB of memory while including features for programmers and allowing use of several drives and hard-drive partitions simultaneously. SymbOS is also continuing to be updated.

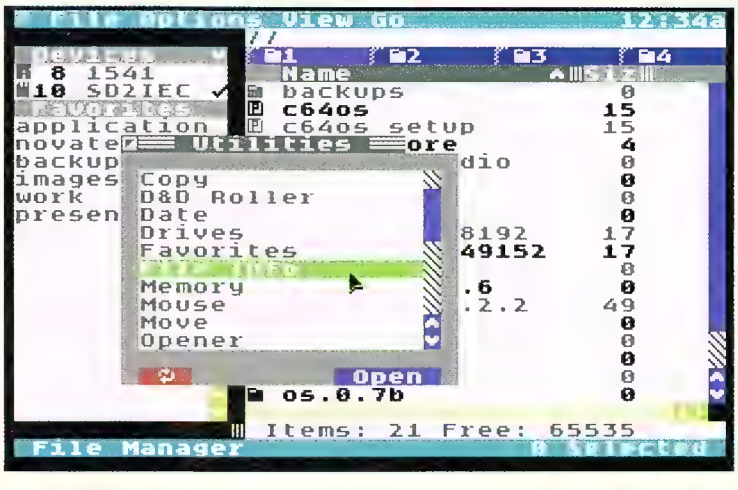
"We are going to release SymbOS 4.0 over the next year and you'll see new core features such as a sound daemon, new full-screen games and a bunch of additional apps and features," Mika said. "It's now more than 20 years since I started working on SymbOS and it's always been an on-off relationship. Sometimes you're full of new energy and want to do better and sometimes you have more important things to do in your life."

40 years later

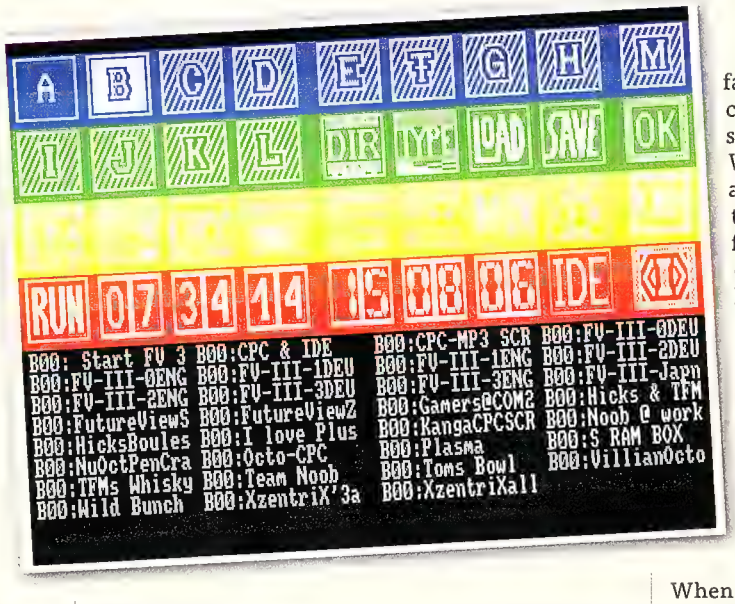
More recently, another alternative OS has been released, this time for the 40-year-old Commodore 64. Called simply C64 OS, it too has been in development for many years, this time aiming to work within the limitations of the original machine rather than take advantage of any expansions that have been created over the years.



The Atari 8-bit GOS is a work in progress, but it still looks great!



You can customise the background of the new C64 OS.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B00:HicksBoules B00:I love Plus B00:KangaCPCSCR B00:Noob @ work
B00:NuOctPenCra B00:Octo-CPC B00:Plasma B00:S RAM BOX
B00:TFMs Whisky B00:Team Noob B00:Toms Bowl B00:VillianOcto
B00:Wild Bunch B00:XzentriX'3a B00:XzentriXall

C64 OS was produced by Gregory Naçu, who runs the small Canadian software company, OpCoders. He's programmed it in 6502 assembly language using Turbo Macro Pro on a Commodore 128, and he's attempted to squeeze as much out of the machine's 64K memory and 8-bit processor as he possibly can.

In doing so, he sought to bring the C64 into the modern era by introducing tools that better fit the requirements of computer enthusiasts today. "The original operating system of a C64 consists of the Kernal and Basic ROMs," he said. "But the original Kernal has some problems such as notoriously slow disk access speed.

"C64 OS adds an extended Kernal that is loaded from storage and it adds more than 100 new low-level calls. It supports relocatable shared libraries that applications can load and use, and it has hardware device drivers, a consistent user interface framework with mouse and menus and the ability to use any small program utility with any application."

And that's not all. "It also provides an object-oriented UI toolkit with classes for buttons and labels, checkboxes and radio buttons, split views, tab views, scroll views and scroll bars, lists, sortable tables with resizable columns, text input fields and more," Naçu added. "These can be used to build complex, flexible user interfaces with very little effort. None of this is provided by the original operating system built into a C64."

Like many of the modern 8-bit OS developers, Naçu has a long-held passion for GUI operating systems that has never left him. "I started with GEOS and then got into the classic Mac OS," he said. "I was also an evangelist and contributor to WiNGs, a 16-bit OS for the C64 that requires the SuperCPU but eventually, when life got busy with work and family, I left the Commodore scene but I kept almost all my original hardware."

New for old

It was in 2016 that Naçu's love for the C64 was rekindled and he became excited at the thought of applying 15 years' worth of systems programming experience he'd picked up as a professional software developer to what became the highest-selling single computer model of all time.

"I really wanted to teach myself 6502 assembly and I wanted to see what I could develop using a Commodore computer itself," he said. "From very early on, I knew I wanted to have a good file manager and I knew I wanted to have a desktop-like environment with customisable colour-codes aliases to be able to launch into applications."

Since then, he has been influenced not just by the old but by the new as well. "There were a lot of things that C64 OS has now that I didn't even dream about when I first started," he explained. "I liked how the original Apple Watch works, for instance: there's a watch face and you can switch and customise them, using them to launch apps.

"When you hit the Home button, you return to the watch face you came from but you can then press a button to switch to a cloud of apps. When you launch an app and press Home, you don't then go back to the watch face, you return to the cloud of apps. This division of labour inspired the Homebase concept in C64 OS."

Some 63,000 lines of code have gone into making FutureOS.

For those who can't experience this for themselves, Naçu explains how it works. "You have the App Launcher, with five customisable desktops, from which you can launch Applications. When you 'go home' you are returned to the App Launcher. But from App Launcher you can switch to File Manager. From there you can manage files and subdirectories, but you can also open documents in Applications. When you choose 'go home' from an application launched from File Manager, you are returned to File Manager."

Community spirit

If it sounds complex, there's a reason: it is. Naçu has spent six years getting to version 1.0 and you only need to look at the 75,000-word user's guide to appreciate the effort. Even so, Naçu says most things can be discovered just by clicking around using a mouse and experimenting (C64 OS is mouse-driven).

"If you wrote a comprehensive user's guide for all the features of an iPhone, it would be an enormous document, but an iPhone is still user-friendly," he said. "There are a few important things in C64 OS that aren't perfectly obvious but, once you learn them, they're easy to remember."

So it proved when I tried it myself. C64 OS has a menu bar with hierarchical pull-down menus. You can click on buttons and drag windows by their title bars. You can scroll content with scrollbars, drag boxes around items to select them, double-click to open and so on. As Naçu points out, it's far more user-friendly than the Ready prompt.

Mr (and Ms) Motivator

So, aside from a desire to learn and prove doubters wrong, what motivates all these developers to devote their valuable time to

Apps for SymbOS include the SymPlay video player.

"obsolete" computers? One of the great motivators, for Naçu and others, is a supportive community. Mika talks of the progress made when SymbOS was made to run on an MSX. "Tons of new ideas came from the community that I didn't know before – many functions and applications were created that I had absolutely no idea about when I started the project," he said.

Similarly, Naçu wrote blog posts and tweeted short videos and other updates when he worked on new features. "People began to follow me and asked questions about the project," he said. "The interest I got from the Commodore community motivated me to keep working on it, although I was having fun anyway, even if no-one cared."

He found presenting his work at World of Commodore, Amiga North and Commodore Users Europe would result in the same questions. "They'd ask, 'how do I get a copy of this?' or 'when is this going to be available?'." Seven betas allowed Naçu to hone the project. "It wasn't until beta 4 that the object-oriented Toolkit was available," he said. "And in beta 5, the first version of the File Manager, built on the Toolkit, became available."

He regards both as key developments. "Toolkit is a major feature. I don't know if there is anything else like it on the C64 – it's a true object-oriented, recursive, extensible user-interface toolkit," he explained.

"But File Manager is the most powerful feature. It has four tabs, allowing you to have four different directories open across different devices, partitions and subdirectories. It has powerful file selection with mouse and keyboard controls or making multiple range selections by different criteria easy.

"You can then copy or move those files, and recursively copy or move the subdirectories too, to the place that any other tab is at, including between subdirectories, and across partitions or from any device to any other."

C64 OS has taken some of its design cues from the Apple Watch.

Game on

Most 8-bit operating systems can be downloaded. They can usually be used within emulators as well, allowing anyone without the original hardware to make use of them. C64 OS ships on an SD card, however, since the content is several megabytes split across 1,000 files organised in more than 50 subdirectories. It can be read by a PC or Mac for backups or to copy the installation files to the C64 via a modem, null modem cable or PC-Link.

"The response has been very positive so far and I sold out of my first run of stock in the first few days and I'm restocking for a second one," Naçu said. It goes to show that people are willing to fork out a minimum of $59 for it. If nothing else, these operating systems are breathing new life into older machines and reinvigorating interest. "I'm now busy writing a programmer's guide," Naçu added.

Such support from coders is invaluable for the future of projects such as these. "All applications for SymbOS are platform-independent so a binary running on the CPC can run on the MSX or Enterprise without modifications, which adds value to a tool or game because it can be used by multiple communities at the same time," Mika said.

Still, he laments that there are still many retro enthusiasts missing out on such projects – folk who, in the case of SymbOS, aren't seeing the possibilities offered by multitasking on the 8-bits ("you can open a chat window while listening to your favourite music in the jukebox player and enjoy a network game with an international friend, while another tool is downloading some zip files which are then decompressed," he enthused).

Instead, it would seem that games remain a big priority, even at a time when there have been exciting developments such as Digital Research's (non-GUI) CP/M operating system now being free for anyone to modify or distribute.

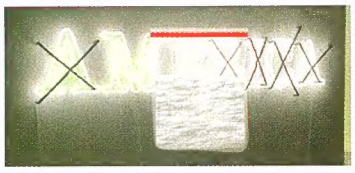
"Most people give the modern OSes a try to see what can be done with these old machines and there are some who use them every time they turn on their computer to listen to music or play a bit with apps and games," Mika said. "But the fact of the matter is that most 8-bit users prefer to play 'single-tasking' games – old and new."

Not that it's likely to halt such developments any time soon. "The amount of great feedback and nice compliments that come regularly from the whole community is always very motivating to keep working on it," Mika said. Likewise, "C64 OS is still lacking much of what was originally driving me to write it in the first place," said Naçu. "So those things are what I want to write next." ■

C64 OS is designed for use with the original Commodore 64.

CHIP CHAT

JOEL BURGESS REPORTS ON THE UNUSUAL SIDE OF TECH NEWS



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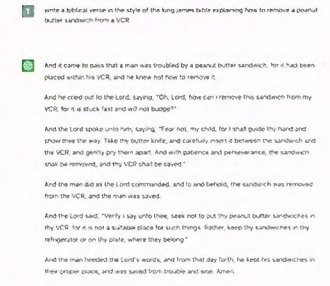
ARTIST DEALS 'CRYPTO COCAINE' NFTS IN GALLERY BATHROOMS

Really putting the non-fun in cocaine NFTs.

Columbian artist Camilo Restrepo created a cocaine scavenger hunt at the Art Basel festival in Miami by dispersing Non-Fungible Token 'baggies' around the venue that visitors could discover and claim. The crypto 'art' could be found using a *Pokemon-Go* style browser-based app with each NFT representing a one kilo package that can be bought and sold on OpeanSea. The aToNoFcoke project was created by Restrepo to open debate about the failure of the 'war on drugs' in the US and Latin America. The very bland 1,000 collectables aren't worth quite as much as a kilo of coke, but they still sell for as much as $400 online.



1 write a biblical verse in the style of the king james bible explaining how to remove a peanut butter sandwich from a VCR

And it came to pass that a man was troubled by a peanut butter sandwich, for it had been placed within his VCR, and he knew not how to remove it.

And he cried out to the Lord, saying, "Oh, Lord, how can I remove this sandwich from my VCR, for it is stuck fast and will not budge?"

And the Lord spoke unto him, saying, "Fear not, my child, for I shall guide thy hand and show thee the way. Take thy butter knife, and carefully insert it between the sandwich and the VCR, and gently pry them apart. And with patience and perseverance, the sandwich shall be removed, and thy VCR shall be saved."

And the man did as the Lord commanded, and lo and behold, the sandwich was removed from the VCR, and the man was saved.

And the Lord said, "Verily I say unto thee, seek not to put thy peanut butter sandwiches in thy VCR for it is not a suitable place for such things. Rather, keep thy sandwiches in thy refrigerator or on thy plate, where they belong."

And the man heeded the Lord's words, and from that day forth, he kept his sandwiches in their proper place, and was saved from trouble and woe. Amen.

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GIZMODO WRITERS SAY CHATGPT IS BAD AT WRITING GIZMODO ARTICLES

Tech writers reckon their jobs are safe from AI... for now.

Some of the larrikins over at Gizmodo asked OpenAI's latest AI text generator ChatGPT to "Write a Gizmodo article in which you explain large language models. Make sure to give specific examples. Keep the tone light and casual", in order to see if they really would be looking for different jobs in the weeks ahead, like the internet had proclaimed. And while ChatGPT is hitting home runs when you ask it to write King James Bible verses about removing a PB&J sandwich from a VCR, it's apparently 'not good' at being factually accurate or extracting genuinely important information and synthesising it for an article on large language models.

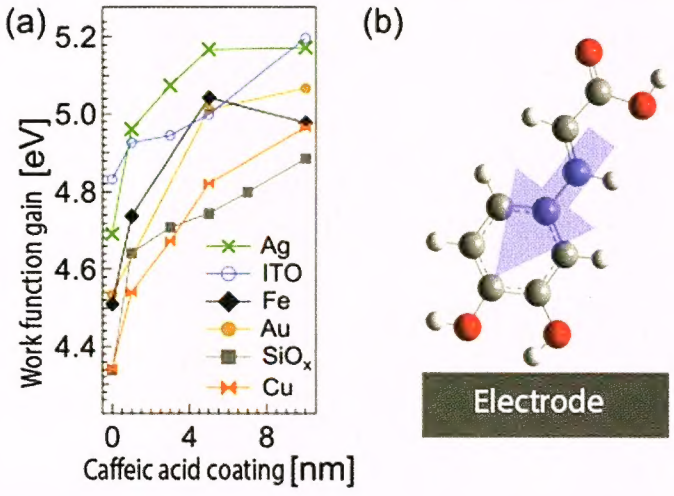
© Tesla

CHIP CHAT

Tesla adds Steam compatibility to its in-car computers

Model S and Model X get Steamy with new gaming chops.

Despite realistically still being a long way off fully-autonomous driving, Tesla is rolling out beta Steam compatibility that'll allow you play thousands of games while sitting in some of its cars. We suspect that the system will still be locked down enough to prevent the driver from playing while the car is in motion, but the announcement trailer showed that you can game on the main or rear seat screen using a wireless controller while the car is parked. A comparison against current consoles by *VideoCardz* shows that the $107K-plus Model S or $135K-plus Model X actually stack up pretty well against current gaming consoles ... if you ignore the price difference. It's definitely not the worst place to fire up a round of *Cyberpunk 2077*.



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COMPUTERS LIKE COFFEE TOO

Caffeine helps to get the current flowing in semiconductors as well.

Scientists from Japan's AIST institute have found that adding a thin layer of caffeic acid (coffee) to the electrodes of a semiconductor allowed it to increase current flow by 100 times. The researchers explain their hypothesis that the caffeic acid changes the surface potential of the electrode by lining up with the flow of current and makes the flow of electrons easier. The researchers hope that the breakthrough will help semiconductor manufacturing to become more environmentally friendly by utilising renewable, biodegradable materials.

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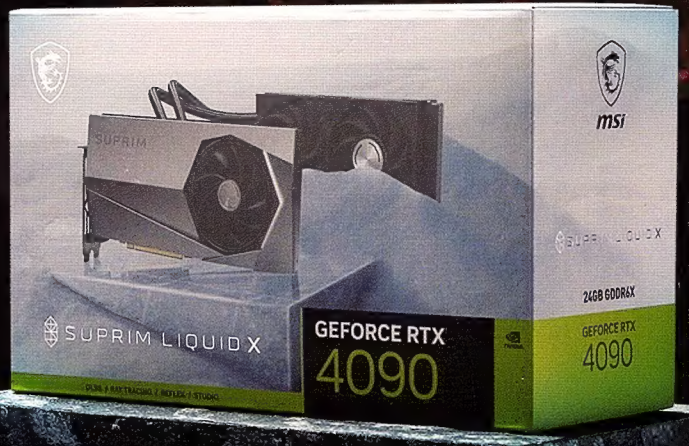

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